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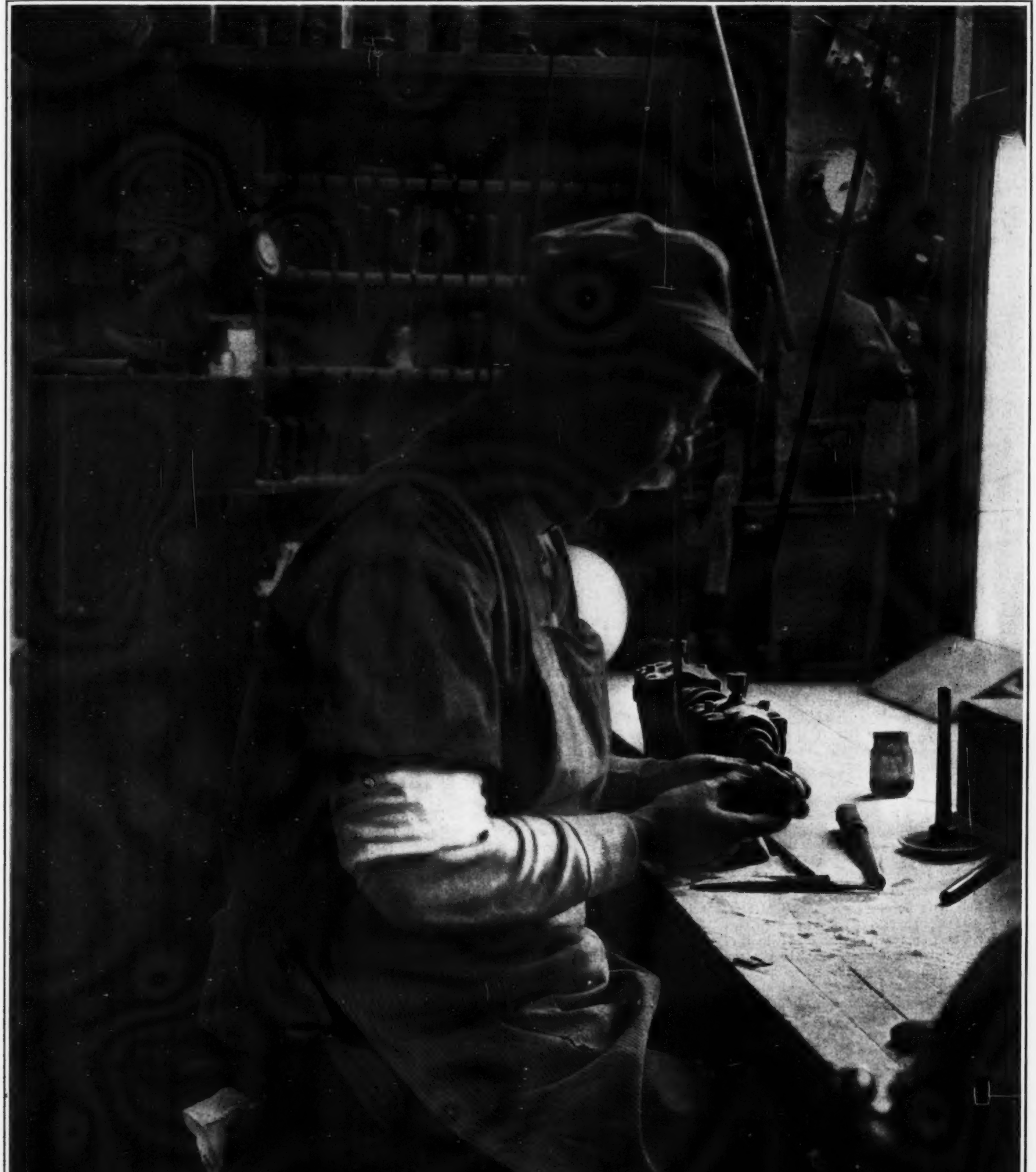


An expert ivory worker doing a delicate bit of carving with a modern machine tool

THE VANISHING ART OF IVORY CARVING [See page 409]

The Relations of Matter and Ether

A Simple Conception of the Evolution of Matter

By Charles Morris

In considering the conditions of ether, which appears to occupy the universe as a plenum, and matter, which is thinly distributed through the vast etheric ocean it is not easy to avoid the conclusion that some close relation must exist between them. The idea has long been entertained that the ether is the seed-bed of matter, the fertile soil from which the material universe has grown. And in this inquiry, the atom, long regarded as the unit of matter, seems to take its place as the first step in the process of evolution, constituting the original agent in this great process. It is, therefore, in the direction of the ether and the atom that physical science has long aimed its attention in its study of the primal conditions of nature.

What has been done in the effort to solve this evolutionary problem? The most that can be said is that a number of tentative suggestions have been offered, none of which has proved acceptable. Only one of them, the vortex-atom theory of Lord Kelvin, has been deemed worthy of special attention, and this was finally abandoned by its projector as unworkable. The question, therefore, was left open.

Within recent years this subject has assumed an entirely new aspect. It has been made evident that the atom is not the unit body so long supposed, but that, minute as it is known to be, it is a composite mass, made up of a large number of far smaller particles, known as electrons. The smallest of atoms, that of hydrogen, is estimated to contain 1,800 of these, and on this basis the largest atoms, such as that of radium, must contain well nigh half a million. And this is not the whole story. While it might reasonably be imagined that the atom, as thus constituted, would be crowded by its contents, in reality it appears to be very thinly occupied. So minute are the electrons held to be that the extraordinary estimate has been made that they occupy the atom space no more fully than the planets fill the space of the solar system.

Such is the status of the research into the unit conditions of matter as it at present stands. It is true that one further step has been taken, one of much interest and importance, it being maintained that each electron is a unit of negative electricity. Thus the electron seems to be at once a unit of matter and a unit of one of the chief energies of matter, it thus occupying a prominent double position in nature's organization. As to the question of the origin of the atom, it has been relegated to that of the origin of the electron, so far as any such question remains open.

It may be, however, that the problem of the relation between matter and ether has been practically lost sight of at the very threshold of its solution; that the discovery of the electron, which has set it aside in its old form, has opened the way to its ready solution in a new and promising form. In fact, this late victory of scientific research may have enabled us to gain a clear outlook into one of nature's deepest mysteries.

Below the atom, apparently very far below it, lies the ether, made up of corpuscles almost infinitely small. But are we not justified in saying the same thing of the electron? It also descends enormously below the atom in size and seems in its turn a tenant of the infinite. The atom itself is known to be of very great minuteness, as measured by our estimate of size, and was long looked upon as making a near approach to the possible limit of the diminutive. Yet it now appears that the electron is as far, or farther, below the atom in size as the latter is below objects visible to our unassisted vision. The electron may then with justice be held to approach, and perhaps even to reach, the final limit in this direction. A question of moment here arises. Can the corpuscles of the ether, its unit particle, be smaller than this vastly minute particle of matter? Are we not warranted in suggesting that these may be in the same category so far as size is concerned? Yet if this is admitted as probable we cannot stop here. If these excessively minute particles, the electron and the ether corpuscles, be similar in size, may they not be similar in other directions? In short, may they not be identical?

If the probability of this conception be admitted, it leads us to consider one of two deductions. On the one hand we would have two etheric agents to deal with, one fitted to convey the waves of light, the other to aggregate into the atoms of matter. On the other hand we would have a single ether, one capable of performing both these functions. If the latter suggestion be accepted the problem of the evolution of the atoms of matter from the ether of space would be solved, since in this case the atom would be a direct outgrowth from the ether.

Such is a brief presentation of a hypothesis of high significance, one that needs to be looked upon from all admissible points of view before it can be either accepted or dismissed. The first thing we are led to consider in this inquiry is that of the probable physical state of the ether, as compared with matter. The latter, as we know, exists under three conditions, those of the solid, the liquid and the gas. In the study of the ether it has generally been taken for granted that it must exist under one of these conditions. That of a thinly distributed gas would suggest itself as the most probable, in view of the lack of resistance by the ether to the movements of the spheres. Yet this would not be in accordance with what has been held to be the chief function of the ether, that of the transmission from sphere to sphere of the rays of light. Transverse vibrations, like those of light, could not be transmitted through a gas, since the irregular movements of its particles would quickly disperse the waves of light. For this reason science maintains that the real physical state of the ether must be that of a solid, a mass whose corpuscles are held within the narrowest limits of vibration. Under no other conceivable conditions could it transmit the waves of light.

But if the ether, as it exists in the broad fields of space, is constituted like matter in the solid state, it does not follow that it must be absolutely confined to this state. It may be capable, under suitable conditions, of imitating matter in assuming other phases of organization, those of the liquid and the gas. Increase of temperature is the agency active in producing these changes of state in matter. May not this agency be capable of yielding like changes in the case of ether?

If the probability of this be granted, if sufficient increase of temperature can convert solid ether into a liquid, and further increase convert it into a gas, a new and broad conception of the relations between matter and ether arises. When matter changes from the solid to the liquid state the vibration of its particles appears to change to a movement of rotation and its form from that of the crystal to that of the sphere, as indicated in the rounded forms taken by liquid drops. Its rigidity at the same time is greatly decreased. If ether may similarly change from the solid to the liquid state, it is logical to assume that accordant changes must here take place, its rigidity decreasing and its type of formation becoming that of the sphere. The result in this case, as in that of matter, would be a group of rotating groups of corpuscles resembling those of water, which, when liquefied, becomes a group of rotating atoms. Thus we are brought to the conception that the atom may be a minute drop of liquified ether made up of rotating corpuscles analogous in formation to the water drop. Have we not here a logical and probable conception of the origin of atoms and of the general relations between matter and ether, in view of the possibility that the ether corpuscles and the electrons may be identical?

There is a further phase of change to be considered, that from liquid into gas. Does this also occur in the case of ether? There is much evidence in favor of its doing so. Under the hypothesis here presented the emission of electrons by radium and other radio-active substances would be an example of ether volatilization. The same would appear to be the case when an electric charge is sent though the highly rarified gas of an exhausted tube. The Cathode rays here given off consist of electrons, and their high speed, closely approaching that of the rays of light, goes far to indicate an identity between them and the ether corpuscles. There is other evidence in the same direction. In both ordinary and wireless telegraphy the electron is now held to be the agent of the electric current, and its enormous speed similarly assimilates it with that of ether in the transmission of light. In addition, the high temperature of the sun and of all the light-giving orbs of space would be a condition fitted for the conversion of ether into the gaseous state, and this is in accordance with the known fact that an abundant outflow of electrons is given off by the sun.

There is one feature in the formation of the unit of matter, however, that remains to be stated. The atom is not made up of electrons solely. It also possesses a more massive constituent, one held to be the unit of positive electricity, which by its attraction of the negative electrons is believed to hold together the atom elements. There is some reason to believe that helium, which is given off by radium in common with the electron and is abundantly emitted by many of the spheres of space, may perform this function in the case of the larger atoms, and a derivative of helium, or some smaller element, now spoken of as a nucleus atom, in the case of atoms of small size. Such is the view at present entertained by recent investigators of this supposed condition.

The function of this larger element of the atom may be an effect of its temperature, if this is sufficiently high to liquefy the solid ether through which it passes. Its action also may be in part on the gaseous ether given off by the spheres, these being condensed around it. It is suggestive to find that the latter case would closely resemble that of aerial vapor, which condenses into raindrops around floating particles of foreign matter in the air, and refuses to condense in air from which such particles have been removed by filtration as demonstrated by the Scotch physicist Aitken.

The hypothesis here presented certainly seems worthy of consideration, as offering a simpler conception of the evolution of matter from ether than any hitherto presented and one in close conformity with the organization of the atom as now known. If accepted it leads to a deduction of much importance. If ether can in the way stated, or in any way, be converted from the solid to the liquid and gaseous states, it is just to presume that it can be further reduced from the latter to its original solid state, as a result of intense chill. If so, the atoms of dead spheres, after losing their heat, may eventually change into the condition of the solid ether of open space, this being the final completion of the great round of evolution. Matter thus dissipated into ether would be in condition for a new evolution into spheral orbs.

Criminal Waste of Natural Gas

In 1914 one of the first wells drilled in the north Cushing field wasted an average of 14,000,000 cubic feet of gas each day for 67 days, or a total of 938,000,000 cubic feet. A little later the same well struck another sand and wasted about 40,000,000 cubic feet of gas each day for seven days, or a total of 280,000,000 cubic feet. From these two sands this well wasted 1,218,000,000 cubic feet of gas, which, if it had been sold at the average price of gas consumed in the United States at that time would have brought $182,700, and even if the producer had sold the gas at the customary field price he would have obtained from its sale over $25,000, or more than enough to drill a well. This amount of gas wasted is equivalent to about 60,000 tons of coal, or about 250,000 barrels of oil, and is sufficient in volume to furnish over 12,000 families with gas for one year. Had this well been the only one to represent waste, it would not have been so regrettable, but as a matter of fact the gas wasted by this well was only a small proportion of the total amount wasted in the Cushing field.

For instance, a well near by, drilled at nearly the same time, in less than a month wasted 1,655,000,000 cubic feet of gas, equivalent to about 80,000 tons of coal. Still another well within two months wasted 600,000,000 cubic feet of gas, and another in 32 days wasted 1,000,696,000 cubic feet of gas. The total combined waste from these four wells was over 5,000,000,000 cubic feet, equivalent to over 250,000 tons of coal, or enough to supply over 50,000 families for one year. If this gas had been sold at the average price of gas consumed in this country it would have brought the seller more than three-fourths of a million dollars.

During the year 1913 it is estimated that in this one field in Oklahoma an average of not less than 300,000,000 cubic feet of gas was wasted daily, or more than 100,000,000,000 cubic feet of this ideal fuel was allowed to waste during the year. This is equivalent to about 5,500,000 tons of coal, and would have met the wants of nearly 1,000,000 families for one year. If the gas had been sold at the rate of 15 cents per 1,000 cubic feet, the sellers would have realized over $15,000,000, and even if the producers had obtained only 3 cents per 1,000 for the gas, which is the prevailing field price, they would have realized over $3,000,000 from its sale. Not only was the gas allowed to waste, but such tremendous volumes of this inflammable material hung over the oil fields that automobiles were not allowed to enter, and in many cases disatrous fires were started, resulting in the loss of life and property.

All this gas was wasted in order to produce about 30,000 barrels of oil daily; in other words, at the prevailing price paid by domestic consumers for such fuel, gas worth about $75,000 a day was needlessly wasted to obtain a daily oil production valued at less than $25,000. —From the *Yearbook of the U. S. Bureau of Mines for 1916.*

Locating Submarine Faults

By Otto Klotz, Dominion Observatory

In the paper on "Velocity of L Waves" by the writer, published in the *Bulletin* for the Seismological Society of America for June last, No. 2, Vol. VII., it was stated that "it is not unreasonable to believe that with high-class seismographs and expert readings of their records we would not only be able to obtain the average position of the epicentre but also the position and direction of the fault line itself." Since the above was written the writer has recently received from Perth, West Australia, a copy of the seismogram obtained there for the earthquake of May 1, 1915, and which was so universally recorded.

In the July-August number, 1916, of this journal the writer published the position of epicentres of earthquakes for the latter half of 1914 and the whole of 1915, in which the above quake is included, and the adopted epicentre was given as N. 49°, and 155°.9 E., being south of Onekotan Island, off the southern extremity of the peninsula of Kamtchatka, and on the margin of the Kurile Deep. It may be stated that in plotting by the stereographic method and using the Klotz Tables the intersection of the various arcs from the stations used did not all intersect exactly at the same point, however the weighted intersection had the above geographical coordinates. Now comes the photographic copy of the gram from Perth, a beautiful record with sharply defined P and S, and which cannot be mistaken. The only regrettable feature is that its time-scale is rather cramped, and the time marks only at the hours. But notwithstanding this slight drawback the deduced distance 9,280 km., even allowing for possible range of uncertainty due to time-scale, shows clearly that the epicentre for this gram was not as far north as given above. Combining the distances of Perth, Zi-ka-wei and Honolulu, the last two the nearest stations to the seismic region, we obtain an epicentre off the island of Urup, *i. e.*, in or along the Kurile Deep. The evidence seems irrefutable that we have an epicentre off Onekotan and one off Urup both on or in the Kurile Deep. Rereading and measuring on the 30-inch globe the various distances of other stations giving good records to the nearest point along the line giving the above two epicentres, better accordances are secured than if we try to join them all to one point—to one epicentre. The conclusion is forced upon one that we have to deal here with a breakdown along a fault line 590 km. long, running in a N. E.—S. W. direction, the trend of the well-known Kurile Deep, and the seat of much seismic action. Perth lies approximately on the great circle passing through the Kurile Deep.

The Perth gram as read here gives P 5 h. 13 m. 36 s., S 5 h. 24 m. 00 s., hence S-P 10 m. 24 s. equivalent to 9,280 km. The deduced 0 is 5 h. 01 m. 09 s., while the mean of Ottawa, Harvard, Berkeley and Eskdalemuir is 5 h. 00 m. 06 s. There is, undoubtedly, an error of a minute in the Perth seismograph clock, but that does not affect the distance nor location of the epicentre. One might advance the argument that the break started at the northern end and was a minute in traveling southward the 500 km., but this will not hold, as the mean of the times of Zi-ka-wei and Honolulu, nearer to the southern than to the northern end of the fault line, is 5 h. 00 m. 12 s., so that the minute clock error of Perth stands out clearly.

It is believed that this is the first instance of an attempt at locating a submarine fault. There is no reason to doubt that in time submarine faults along which seismic disturbances occur will be definitely located in all the oceans. This knowledge will have a thoroughly practical bearing on submarine cables, in determining the position of breaks, which is determined electrically by the cable itself as explained in the article "Cable Laying," pp. 404-407, by the writer, in the volume "Annals and Aims" of the Pacific Cable, 1903; and also in future cable laying in pointing out dangerous lines to be avoided for the cable route.

With reliable seismograms, and more particularly with accurate and correct interpretations, a wide panorama of interesting and valuable results looms up. The location of epicentres will expand to location of fault lines, and, furthermore, when our absolute times of record are reliable within a second we will have the means of following the breakdown from beginning to end. At present we deal with earthquakes on the assumption that it is one sudden break at a point or along the line or surface of adjustment of stresses. If this is not the case the comparison of seismograms from different stations well distributed about the seismic area will tell us the story of what happened, when it happened, how and where, as well as how much energy was released in the adjustment. It is believed that there is already a great deal of material on hand in the form of seismograms that, if brought together and dealt with by a master hand, would reveal much of the interior of the earth, would furnish us material for improving and extending our tables and velocity curves, so that we would reach the stage of detecting along certain paths of the seismic rays anomalies in density, elasticity and rigidity, thereby extending a helping hand to the investigator of gravity anomalies. At present coordination and collaboration are required. In closing this brief note it may be pointed out that when the earthquake is one sudden breakdown, then the 0's for all stations must theoretically be the same. But the epicentre deduced from various pairs or groups of stations will not necessarily be the same, as is obvious when we consider the disturbance to occur along a fault line of considerable extent. The P and S at each station would come from the nearest part of the fault line. It may be observed that although Galitzin was able in many instances to give from the records of one station supplied with his instruments, one with the two horizontal components and the other with vertical component, the approximate position of the epicentre yet the offsets he has to measure on the seismogram to get the azimuth are so small that the range of the resulting position of the epicentre is much larger than the position obtained from the intersection of two arcs, by the method usually pursued. The Galitzin method was an achievement of high merit at the time, but it can not in accuracy compare with a determination made from three stations with good grams. It is hoped that this short paper will stimulate others in the analysis of the records of seismograms with the view not only of the location of epicentres, but of fault lines if they participated in a seismic disturbance.—*Journal* of the Royal Astronomical Society of Canada.

Illusions of the Atmosphere and the Traveling Vortex

Lecturing at the Royal Institution in the two past weeks on "Illusions of the Atmosphere," on which he had discoursed two years ago,* Sir Napier Shaw, F.R.S., director of the Meteorological Office, pointed out that no ground was so fertile in illusions as the study of the weather. The repetitions of the weather, weather phases, the influence of the moon, the significance of the barometer height—all were illusions, sometimes with the amount of truth that a first-class illusion required. Even the introduction of the weather map had given rise to a fresh store of illusions. A cyclone—the barometric "low" of the Americans—was regarded as a region to the centre of which air converged in spiral paths to rise in a continuous stream producing the rain characteristic of the cyclone, its place being taken by the air descending in the central region of an anticyclone—the "high"—and diverging thence in spiral paths. That picture was misleading, and Sir Napier devoted his lectures mainly to the very complicated dynamics of a revolving column of fluid in their meteorological aspects; his conclusions had not been published so far. The appearance of the weather map, he stated, suggested the picture of a cyclone as a column of fluid revolving about a vertical axis which had its foot in the centre of the cyclone. That was probably true, in a sense, but the axis of the cyclone was not the axis of revolution. The air might revolve like a solid spinning top, the velocities of the particles being proportional to the distances from the centre, or the velocity distribution might be uniform over the cyclone area. Assuming the latter distribution, the velocity lines would, on a disc, be concentric circles at equal distances apart; the separation of the lines was understood to be inversely proportional to the flow. When a uniform pressure field was superposed upon the whole system (spinning from west through south to east), causing the system to travel east, the lines would become crowded in the southern portion of the disc, and the circles would turn into ellipses, parabolæ or hyperbolæ according as the velocity of translation was greater, equal to, or smaller than the velocity of rotation. On the earth's surface the velocity distribution would not be so regular; but the isobars, especially at some height above ground, should show the vortex character. As a matter of fact, the weather maps of great storms, the rainless storm that visited Cambridge on March 27, 1895, the storm of October 27, 1913, which formed a thunderstorm track straight north through Devon and Wales and had its cyclone centre far out west in the Atlantic, etc., were not at all remarkable. Thus, a fast-traveling vortex would not look like one on the map, but would be represented merely by deformations of the isobars amounting to little more than indentations. With the assumed uniform velocity distribution it was difficult to imagine a force so adjustable to each particle as to push the whole system along a certain path. That was possible, however, when the whole column was assumed to spin like a solid. When the superposed pressure field was such as to push the column to the south, the column would be transformed into a cyclone traveling east, and the spin would be about the "tornado centre," at a distance V/w from the "cyclone centre," if V were the speed it was desired to impress and w the rate of angular revolution. The appearance would be that of a horizontal disc floating down stream while spinning in its own plane, or of a carriage wheel which looked as if instantaneously rotating about a point on the ground whilst obviously turning about the carriage axle and advancing with the carriage. The air particles described loop-paths in entering and leaving a cyclone. The traveling cyclone was then only part of a travelling column of revolving fluid, which had three centres: the tornado centre mentioned; the cyclone centre about which the winds circulated (in irregular fashion, apparently); and the dynamic centre of the isobars. If a small whirl descended from the upper atmosphere and met a uniform pressure field, the foot of the disturbance would not be vertically underneath the whirl, but would be laterally displaced; hence the "elephant-trunk" appearance of whirls and water-spouts.—*Engineering.*

*See *Engineering*, March 17, 1916, page 263.

Tire Substitutes for Passenger Automobiles

During the last year various substitutes have been devised for pneumatic tires on passenger automobiles; these substitutes being practicable under war conditions, though not entirely satisfactory. The decree of December 18th, 1916, relaxed the law restricting the speed of vehicles with other than rubber or similar elastic tires to 25 km. per hour. The decree of April 24th, 1917, recognized six patterns of substitutional tiring as permissible until further notice.

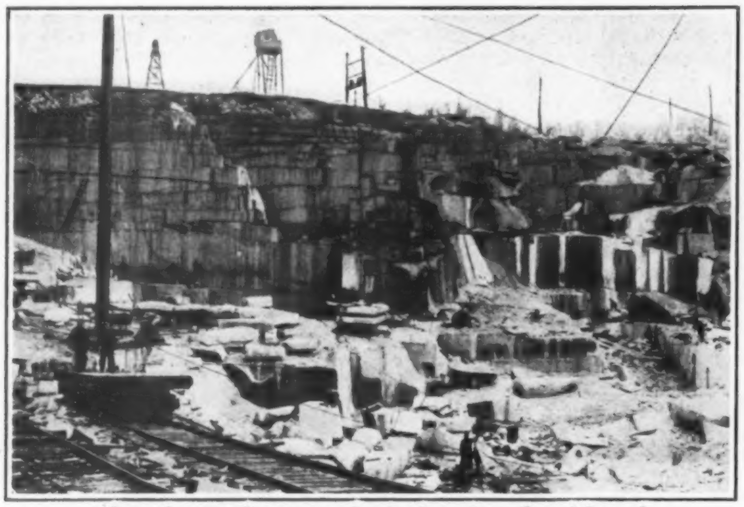
Substitutes for pneumatic tires fall into two classes: (1) Those with a rigid rim of metal or wood capable of moving only in the direction of the spokes. (2) Those in which "spoke springing" is supplemented by a species of "rim springing," *i. e.*, a flexible outer rim in addition to springs between the two rims. Typical examples of both types of tires are given in the original.

The Arop wheel is simple and effective. A single or a double row of spiral springs wound from square steel is carried by dowelled spring plates or mountings between an inner and outer rim; but this arrangement is not suitable for high-speed vehicles because the springs are not secure against displacement by lateral forces when running round curves or over obstacles. This risk is eliminated in the Moll wheel by placing each spring between two end caps which are spherical on their outside, and provided with tubular extensions down the inside of the spring. One of these extensions slides within the other, forming a telescopic combination which prevents lateral displacement of the spring, while the spherical ends permit lateral displacement of the rim.

The special advantage of the Fruth wheel, built by the Maschinenfabrik Augsburg-Nürnberg is that the springs are protected against bending or displacement by the peripheral force accelerating or retarding the vehicle. Oval springs are placed between the inner and outer rim on their sides, so that the wheel pressure comes in the plane of the winding. Successive springs are overlapped (going circumferentially round the wheel), and crossbolts pass through the overlapping loops. The springs lie in two U-troughs which fit one within the other and relieve the springs from all transverse forces. The outer rim and the complete spring system can be mounted as one piece on the inner rim as substitute for a rubber tire. Replacement of broken springs is not easy.

The Sievert wheel uses a composite wooden rim (part of its timber being cross-cut) with steel side rings, between which and the sides of the inner rim are rings of rubber or other elastic material. The whole load is transmitted through the rubber side rings; these have a long life, since they are protected by the side plates. Wear comes on the wooden road rim.

The Siemens and Halske wheel uses spiral springs mounted radially between cups attached to the inner and outer rims. In addition, the outer rims consists of continuously wound strip steel secured by cross clamps at intervals and protected by leather or similar material which is riveted on and renewed as required. The springs are inadequately protected against dirt and against transverse forces, but the elastic rim improves the smooth running of the wheel and reduces the risk of side-slip. The Flohr wheel is of similar construction, but the outer rim is built up on the same principle as a link belt. The link-pins serve as supports for the spring cups on the outer rim, but they are not protected against dirt and water.—Note in Science Abstracts on an article by A. Heller in *Zeits, Vereines Deutch Ing.*



Scene in a granite quarry, showing layer formation of the rock

A close-up view in a quarry, illustrating the magnitude of the work

Monument Mines

The Granite Hills of Vermont Furnish the Best Materials

By Le Roy Kenneth

THE custom of marking burial places is as old as humanity. When we build a house we build for a lifetime; but when we erect a monument it is for eternity. Marble, steel, and cement are satisfactory for buildings; but for monuments we burrow deep into the earth for the most enduring material, the rock evelasting—granite.

In many ways granite is like natural glass both in composition and the process employed by nature to make it, and it holds all the valuable qualities of glass except transparency. It is the hardest of the rocks, lowest in absorption of water and consequently the most durable. It is more impervious to the ravages of time and weather exposure than any other known material.

Of such rock there is an abundant supply in nearly all mountainous regions. But being the lowest rock formation and being squeezed to the surface by the earth's contraction it is usually shattered and broken up, mixed with all kinds of impurities, inconsistent in color, and variable in texture. Only in small spots are deposits of value found in which the color is evenly distributed and the texture uniformly maintained, and the grain close enough to be impervious to weather ravages.

American mountains have yielded much that is beautiful, much that is of almost priceless value. They have given us gold and silver, and metals for more practical uses, and minerals of uncounted worth, and precious stones. Out of a spot less than two miles square in the Green Mountains at Barre, Vt., comes the largest part of the granite used for memorials in this country. It is the largest granite producing center of the world and 99 per cent of the granite from these quarries is used for monuments.

In 1781 the "hard stone" discovered at Barre was used for making millstones. At that time the millstones were conveyed by oxteams for very great distances. The hardness and wearing quality of the material made these stones more desirable than the imported burrstones from France, because of their durability.

Last year these old millstone quarries produced 1,500,000 cubic feet of granite for memorial pruposes. The size of block is governed by transportation limitations and derrick capacity. The largest piece ever loosened was 200 feet long, 50 feet wide, and 24 feet thick, weighed 69,000 pounds and, unbroken, would have made 1,700 carloads.

The granite is formed in layers, the upper stratas are seamed and broken; but beneath is the monumental stone of dignity, durability and beauty.

Steam drills drive channel holes 35 or 40 feet deep, the layer is slpit away by blasting, broken into desired sizes, raised from the pit by boom derrick sometimes 150 feet to the surface.

The rough block by the art of a sculptor may become a statue or piece of delicate carving, permanent evidence that we still live in the hearts of those we leave behind.

Ancient Plant-Names*

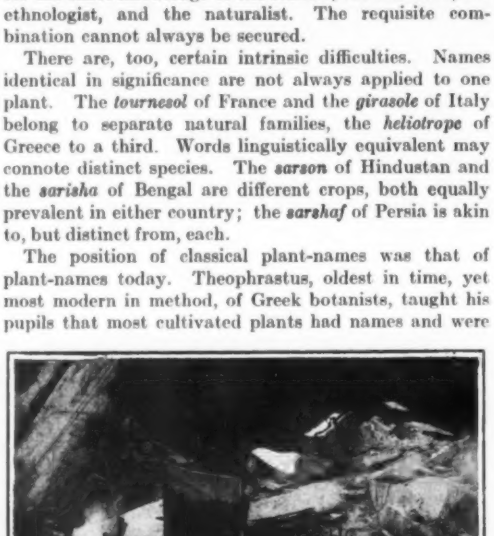
THE antiquity of plant-names needs no proof. We read in Genesis how man, early in his career, came to designate living things, and learn the name of the tree from which he improvised his first raiment. Semitic tradition is corroborated for other regions by Chinese ideographs which admit of comparative study and by Aryan vocables that lend themselves to ethnic generalization.

*"On Some Ancient Plant-names." III. By Sir W. T. Thiselton-Dyer, K.C.M.G. *Journal of Philology*, Vol. xxxiv, pp. 290-312.

The results of the study of ancient plant-names are only satisfactory when the incidence of the names is assured. But assurance is not easily attained. The work calls for the exact knowledge of the scholar, the historian, the ethnologist, and the naturalist. The requisite combination cannot always be secured.

There are, too, certain intrinsic difficulties. Names identical in significance are not always applied to one plant. The *tournesol* of France and the *girasole* of Italy belong to separate natural families, the *heliotrope* of Greece to a third. Words linguistically equivalent may connote distinct species. The *sarson* of Hindustan and the *sarisha* of Bengal are different crops, both equally prevalent in either country; the *sarshaf* of Persia is akin to, but distinct from, each.

The position of classical plant-names was that of plant-names today. Theophrastus, oldest in time, yet most modern in method, of Greek botanists, taught his pupils that most cultivated plants had names and were



Lifting a great block for a monument from the quarry

commonly studied, but that most wild kinds were nameless, and few knew about them. Yet European study of ancient plant-names is mainly that of Greek ones. As Sir W. T. Thiselton-Dyer has pointed out in Whibley's "Companion to Greek Studies," the Greek botanist had a name for every conspicuous Greek plant, and most of these names have come down to us, whereas nothing of the kind, if it ever existed, has survived from the Romans.

Renaissance students endeavored to identify the plants described by Dioscorides. Their texts show great critical acumen; their illustrations are often most faithful. Yet much of their work is obsolete. Their appreciation of the principles of plant-distribution was imperfect. They sought in Central Europe for Mediterranean species, and often were in error when they felt most assured. It took the European naturalist three centuries to realize this; even yet the European scholar does not always appreciate the situation, and standard lexicons sometimes still remain "blind leaders of the blind." Until, two years ago, when Sir W. T. Thiselton-Dyer gave us a compact enumeration of those plants actually Greek with which it is possible to wed a Greek name, no scholar and no naturalist in this country had any real assurance as to the accuracy of any accepted identification.

The same author has now, in the paper cited in our footnote, dealt with a special group of ancient plant-names, mostly Greek. With a restricted arable area and an extended seaboard, ancient Greece possessed an adventurous mercantile marine. The list of Greek names for cultivated edible, official, and coronary plants, or for wild species of economic interest was supplemented by one of names for plants or plant-products from abroad. The resolution of such exotic names is, not unnaturally, often most perplexing.

The aid this new contribution renders to the subject to the scholar and the naturalist cannot well be measured. Both can best repay their obligation by studying it with care. The space at our disposal forbids any attempt at its analysis. The account of ἄμωμον and καρδάμωμον, terse yet complete, carries instant conviction. The problem of the Idæan vine, the solution of which by Dodoens three and a half centuries ago has, as the author explains, been generally overlooked, amply merits restatement. But the other sections equally deserve unstinted praise. It may yet be necessary to modify in detail the conclusions reached regarding ὀποκάλπασον. This cannot, however, lessen the value of a note which manifestly puts the special student on the real track of this elusive bane, and gives the scholar something better than the old lexicographic acceptance of its identity with an innocent gum. The traveler responsible for that self-contradictory conclusion could justify it only by the assumption that Galen had been misled. This note may also spare us the repetition of a contrary suggestion, less consonant with phytogeographical considerations than anything ever hazarded by a Renaissance scholar, that in ὀποκάλπασον the ancients had somehow come into contact with the West African ordeal-tree. —*Nature.*

Fodder Substitutes in Germany and Sweden

IT has been ascertained by experiments that dried wood-pulp cellulose is quite suitable for cattle food when mixed with molasses and albuminous substances. Some of the largest cellulose mills in Sweden are making energetic preparations for turning out large quantities of the fodder in the spring, and the yearly output is expected to be about 20,000 tons. A high official in the Swedish Board of Agriculture states that its nutritive value is greater than that of hay, and that about 75 per cent of it is digestible. The manufacture of straw fodder in Germany is now an important industry. In Sweden its production is curtailed owing to the scarcity of soda lye used in the process of manufacture. Reindeer moss and Iceland moss are now extensively used for fodder in Sweden, and experiments in the use of rushes as food for horses have met with satisfactory results. Heather has of late been coming more and more into use as a fodder substitute, and if prepared from slender sprays of the plant it is particularly useful for feeding horses. Leaves of various trees, particularly birch trees, are now being used as fodder in Sweden; and in this country new areas have been planted with rape, both for the production of oils and fats and for the manufacture of cattle cake. Quickgrass, after drying and chopping, is devoured eagerly by pigs, and these animals are also found to thrive on dandelion roots. One method employed is to boil the roots together with quickgrass before use. A strong food for cattle is prepared in Germany from glue, and another from yeast.—*Jour. Soc. of Chem. Ind.*

A view in a granite quarry at Barre, Vt. Powerful derricks are necessary to move the heavy blocks required for monument work

Steam drilling machines driving lines of holes to enable large blocks of stone to be split out of their beds in the quarries

The Origins of the Chinese

At a recent meeting of the Anthropological Society of Washington (D. C.) Mr. Edward T. Williams, Chief of the Division of Far Eastern Affairs, Department of State, presented a paper on the above subject. Four theories regarding the origin of the Chinese that deserve examination were outlined as folllows:

The first, advocated by Dr. L. Wieger, a missionary of the Society of Jesus, is that they originated in the Indo-Chinese Peninsula. His reasons for so believing are, briefly, that

1. The Chinese ideograms have existed since 3000 B. C. and the most ancient represent tropical animals and plants, thus pointing to a tropical country as the place of origin for the race.

But the oldest Chinese ideograms known to the world are not older than 1200 B. C., when the Chinese were already settled in the valley of the Yellow River and in constant intercourse with their neighbors to the south. These ancient ideograms, moreover, represent animals and plants of the temperate zone rather than of the tropics. Those for sheep and cattle are found, too, in many root words, indicating that the early Chinese were shepherds and herdsmen, pursuits not found in tropical countries.

2. Other reasons given for a tropical origin are that the oldest form of the Chinese language is found in southern China today.

3. The Chinese language is purest in the south and grows more and more corrupt as one approaches the north.

4. The Chinese language is tonal, as are the languages of Indo-China, and is therefore most nearly related to these.

It is not necessary, however, to assume a southern origin for the race to account for these facts, which are just as easily explained by the arrival of the Chinese from the north in successive waves of migration, the later comers crowding the earlier further and further towards the south, so that the oldest and purest forms of Chinese would be found just where they are. The tonal languages of the Indo-Chinese Peninsula in that case are to be regarded as the languages of the vanguard of the migration.

As a matter of history it is now known that many tribes of Cambodia, Siam, and Burma came from the north, the Tibeto-Burmans from a region as far north as the Tien Shan. Some social or physical change forced these tribes to migrate. The dominant element in the population of Burma did not reach that land until about two or three thousand years ago, while the tribes of Cambodia arrived in their present habitat about 215 B. C. and the Shans, progenitors of the Siamese, ruled southern China until the thirteenth century of the Christian era. The movement of races therefore has been from north to south and not vice versa.

The second theory is that the Chinese originated on the American continent. This theory does not require much attention. There have been movements of population, it is true, from America to Siberia, even in historical times, and there is cultural and phyisical similarity if not identity of the peoples on the opposite shores of the northern Pacific. But the tribes of which this is true lie to northeast of China and differ strikingly from the Chinese in physical appearance, language, and social institutions.

The third theory is held by a number of distinguished scholars and declares that the Chinese are autochthonous and their civilization indigenous. It must be admitted that the oldest existing records of China seem to know no other region as the home of the Chinese forefathers than the valley of the Yellow River, and it is held accordingly that they gave up nomadic habits and settled as agriculturists there in an unknown antiquity and that it was there that they developed their civilization, including their written language. As to the last-mentioned the theory is almost certainly wrong. This civilization, including the use of the ideograms, appears to have been shared by surrounding tribes, from among whom in fact some of their most famous rulers came.

One of these tribes, the Chou, headed a league of nine tribes from the west which subdued the Shang Dynasty about 1200 B. C. These tribes were amalgamated with the earlier and much of the culture of China must be

Handling an immense monolith in the yards. Note the mountain of waste material in the background

ascribed to the Chou. This fact and the enforced migration of the Mon-Khmer, Tibeto-Burmans, and Shans to the south because of some disturbance apparently in central Asia, gives plausibility to the fourth theory.

This theory would place the origin of the race in central or in western Asia. A number of distinguished scholars have held this view. Pumpelly's explorations in central Asia have shown that that region was the seat of an ancient civilization as old as 8250 B. C. Great climatic changes have there converted what was once a moist and fertile land into an arid desert and caused the inhabitants to migrate to other parts of the world. It was this perhaps that drove the Sumerians into the Euphrates valley and that forced other peoples down upon the Tibeto-Burmans and caused the movements of population in China. The earliest Sumerian monuments show that people to have been Turanian, not Semitic, and to have had obliquely-set eyes. Dr. C. J. Ball, of Oxford, has shown that there are striking resemblances between the earliest Sumerian ideograms and those of the Chinese. He has also published a vocabulary of more than a thousand words which show similarities of sound and meaning in Chinese and Sumerian. This lends weight to the theory that both have a common origin and that the peoples were probably related. Most of the mounds of central Asia remain to be explored and it is not too much to hope that, in the not far distant future, evidence may be found establishing conclusively that the Chinese race originated in that locality.

Gunfire and Rainfall

An editorial article entitled, "Gunfire in France, Rainfall in England," by Dr. H. R. Mill, in the February issue of *Symons's Meteorological Magazine*, comprises an analysis of the monthly rainfall returns for the south-eastern and north-western districts of the British Isles for the wet period 1909-17, considered in subdivisions of two three-year peace-periods and one three-year war period. The rainfall for each month and for both regions is given in percentage of the thirty-five-year average, 1875-1909, the stations utilized being those employed in "British Rainfall," as specially representative of the districts. Without exhibiting the data, it is impossible in the space at our disposal adequately to deal with the salient features of the investigation; suffice it to say that, in Dr. Mill's words, "They bear very strong evidence to the effect that the abnormalities of the rainfall of the war-years are merely the natural development of changes which have certainly been at work for nine years, and in one case no less certainly for fifty years." This last reference is to the increasing dryness of September, shown by Dr. Mill to have been a feature of the climatology of the British Isles during the past half-century, and is, indeed, a matter of common observation. Attention is directed to the noteworthy fact that not one of the four war Septembers has had so much as average rainfall. It is important, moreover, to observe that while 1915 and 1916 had both an excess rainfall of 21 per cent in southeast England, 1917 (which certainly witnessed no relaxation in the activity of artillery), was a year of nearly normal fall (+4 per cent). In the same number Mr. F. J. Brodie replies to those who have criticized his treatment in the issue of December, 1917, of the same problem, and incidentally suggests a statistical process by which he considers it might be possible definitely to decide the point at issue.—*Nature.*

A New Wax from South America

A wax used for candles in Colombia is yet unknown to the outside world, as it has never been exported. It is obtained from the leaves of the wax palm of the Andes, which is reported to be very abundant in western tropical South America, but occurs nowhere else. A sample of the powdered wax lately examined at the Imperial Institute, London, was of a pale-straw color, with a small admixture of vegetable matter. When purified it was found to resemble other American waxes. It has a melting point as high as 93 degrees Cent., while that of carnauba wax from Brazil is 84 degrees, and that of candelila wax from Mexico is only about 70 degrees.—*The Engineer.*

Making Cast Ammunition in France*

How Semi-Steel Shells Are Made—Composition and the Physical Properties

By E. Ronceray

THE war which has been engaging the attention of the civilized world for nearly four years has made necessary the introduction of new processes in the foundry as well as in other industries. The need for ammunition is great and exceeds what was conceived to be necessary, even by the most visionary. It is a well-known fact that five weeks after the declaration of war, the battle of the Marne ended when the French and Germans had practically exhausted their entire supply of shells. It was a tragic and critical moment and every means was resorted to to obtain shells, even though imperfect.

It was at this time that practice shells, made of cast iron and containing only a small amount of explosive, were used and these were produced as quickly as the foundries could turn them out. The 75-millimeter (2.96 in.) steel shell gave such excellent results that every effort was made to secure them and even small shops were asked to bore and thread steel bars to produce these shells in two parts, one for the body and one for the cap. This imperfect type of shell and that made of cast iron saved the day for the 75-mm. rapid fire gun which was the most important weapon in use at that time. Steps were taken immediately for the manufacture of forged shells on an extensive scale and the output at present is so great that we are furnishing large quantities of them to our Allies.

A different problem was presented in providing shells for the large guns. With the increase in the diameter of the shells, manufacturing difficulties increased more rapidly. More time was required to make the large shells and to organize for their production in large quantities. It was then that the feasibility of using cast shells was seriously considered.

It is well known among ordnance experts that the destructive effect of a projectile increases in proportion to its size more rapidly than the weight of the explosive it contains. Therefore, steel had the preference for shells in spite of the great cost of the raw material and the high cost of machining. Cast iron shells used as substitutes for steel were of a small capacity on account of the great thickness of wall it was necessary to provide, to insure adequate resistance to the ballistic action of the powder.

SEMI-STEEL SHELLS

The *fonte acieree*, that is, cast material and what is known as semi-steel, was considered and was selected finally for producing a comparatively cheap, quickly manufactured and reasonably effective shell. The Germans can vouch for this. Since the beginning of 1915, an enormous number of these projectiles from 80 to 400 mm. (3.15 to 15.71 in.) have been made and fired for the cause of civilization. In addition to the semi-steel shells, an enormous amount of grenades and projectiles of all kinds have been made of cast iron in France.

The metal required for semi-steel shells was defined by the following data, based on the tests made in this country by the ordnance authorities and railroad companies. The test piece is a square bar, 40 x 40 x 200 mm. (1.57 x 1.57 x 7.85 in.) long, cast on end in green sand with a riser. It is tested on two knives spaced 160 mm. (6.30 in.) apart, by a falling weight of 12 kg. (26.41 lb.) The initial drop is from a height of 28 cm. (11 in.) and the weight is raised 1 cm. (0.254 in.) after each blow until rupture occurs. The average breaking height must not be less than 45 cm. (17.71 in.)

The tensile test piece is 18 mm. (0.71-in.) in diameter x 150 mm. (5.91 in.) long, cast on end and turned down to 16 mm. (0.63 in.). The breaking strain must not be less than 25 kg. per sq. mm. (39,900 lb. per sq. in.)

Hydraulic tests of 10 sec. duration, before banding, are made at a pressure of 300 kg. per sq. cm. (4,500 lb. per sq. in.) for the shells up to 160 mm. (6.30 in.) and 200 kg. (3,000 lb. per sq. in.) for the larger sizes. Other tests after banding are made with compressed air or steam at 5 kg. per sq. mm. (75 lb. per sq. in.)

A reasonable allowance is made for small defects difficult to eliminate entirely in practice, particularly when a great production is required. Small defects externally in front of the band are passed provided their thickness can be determined exactly with a needle and extend into the metal less than one-fourth of the wall thickness.

No defects are permitted at the back of the band except small, interior depressions due to imperfect coring, provided that the thickness is not more than 2 or 3 mm. (0.079 to 0.118-in.) and that the bottom of the shell is sound.

*From a paper prepared for the American Foundrymen's Association. The author is a member of the association and lives at 9 Rue des Envierges, Paris, France.—Reported in the *Iron Age*.

COMPOSITION OF THE METAL

No definite analysis is enforced provided the physical tests are satisfactory. In fact, the metal is a low phosphorus, low sulphur and low carbon iron with a sufficiently high amount of silicon and a sufficiently low amount of manganese to leave it soft under the conditions of pouring. Typical analyses of semi-steel shells follow:

	Diameter of Shell 150 mm. (4.74 in.), Per Cent.	Diameter of Shell 155 mm. (6.11 in.), Per Cent.
Total carbon.......	3.25	3.06
Silicon.............	1.34	1.17
Manganese.........	0.66	0.61
Phosphorous........	0.08	0.08
Sulphur............	0.10	0.17

To obtain a very strong metal it may be melted either in an open-hearth or electric furnace, which insures a low carbon product with some degree of certainty, or by mixing cupola and converter metal. Thermic treatment will considerably improve the physical qualities. Tensile strengths of 35 to 40 kg. per sq. mm. (50,000 to 57,000 lb. per sq. in.) have been obtained regularly by these processes. This metal, however, increases the casting difficulties as it has a tendency to develop blowholes owing to its lack of fluidity. However, for the heavy tonnages required in a short time, the cupola, well handled, gives satisfactory results and regularly produces metal that passes the necessary physical tests. The bulk of the semi-steel shells made in France, either for the Allies, or for ourselves, have been cast of cupola metal.

THE CUPOLA AND ITS EQUIPMENT

The standard cupola, as built in America, is capable of producing good semi-steel. The tuyeres, usually one or two rows close to each other in large cupolas, must be of the standard type, that is, flat and one-sixth to one-fourth of the section of the cupola. It is advantageous to employ a cupola, equipped either with a hearth for holding a certain amount of metal, or provided with a receiver. The use of a receiving ladle is not recommended, as very hot metal with regularity of composition is essential. If a cupola equipped with a receiver is employed, provision must be made to heat the receiver while hot before pouring, or the first metal will be dull.

A blower of ample size is required and it is more advisable to have one of too large a capacity than one that must be driven to the limit to provide sufficient blast. I prefer a positive pressure blower to a fan, as the former insures better control of the melting.

SAND LINING FOR THE CUPOLA

The best lining is none too good as all operating conditions are against its long life. The extended heats necessitated by the large outputs required, the exceedingly hot temperature needed for good metal, the large amount of coke burnt at each melt combined with its low quality at the present time and the large amount of limestone generally used, result in the rapid wear of the lining. Owing to the high cost and scarcity of refractory material in France, many foundrymen have adopted sand linings and it must be admitted that in a great many instances these linings have given equal, if not better results, than refractory brick. A good refractory sand is selected for this purpose and it should be rammed hard between the shell of the cupola and a wood form. It is then carefully dried and blacked. In wearing qualities it compares favorably with the best refractory brick. A thick lining, 12 inches or more, is recommended.

The proportion of steel used in the mixture depends on the composition of the initial iron. If low carbon irons are employed, the amount of steel added must be less than if high carbon pig is used in the mixture. As a rule, the hematite irons now supplied contain more carbon than required, cold blast iron with low carbon content not being produced here in large quantities. Therefore, it is necessary to add a large amount of steel to the charges in order to reduce carbon in the final product. It is admitted that in the cupola process, steel before melting, absorbs 1.6 to 2 per cent of carbon. Taking this into account it is easy to calculate how much steel must be added to reduce the carbon percentage to the correct point. In French practice, up to 40 and even 50 per cent of steel is used. The amount generally charged, however, is from 15 to 30 per cent, according to the quality of the initial iron.

COMPOSITION OF THE FINAL PRODUCT

The final product varies for different sizes of shells and according to the methods of molding pursued. The shell casting must be softer for the smaller projectile, or more exactly, for the thinner shell, and also it must be softer when the metal is poured in green sand molds than in dry sand. The physical properties of the test bars do not measure the final quality of the product. Therefore, test bars from the projectiles themselves are necessary. Such tests, together with actual firing practice, have shown that the best results are obtained when at least 20 per cent of the total carbon is in the combined form, this percentage being as high as consistent with the possibility of machining the shells. The total carbon is kept at about 3 per cent. Less than 2.75 per cent gives a sluggish metal which is difficult to handle and liable to produce unsound castings. Above 3.25 per cent carbon results in the production of castings that are too weak.

Several methods are pursued for controlling the combined carbon. One is to alter the amount of silicon; another is to change the amount of manganese which seems to act in opposition to the silicon, and a third is to change the speed of cooling. Silicon precipitates carbon in the graphitic form and, consequently, reduces combined carbon; manganese has a reverse action, while combined carbon increases with the speed of cooling.

Since the amount of manganese in the iron and steel we are using is about right, it has not been the practice to vary their percentages according to the silicon content. The speed of cooling is not easy to control and the only consideration given this factor is in connection with the change that takes place when the thickness of the shell is varied or with the adoption of dry, or green sand molding methods. Silicon is the element most easily controlled and it is due to its control that semi-steel shell manufacture has been successful in this country.

To arrive at the minimum amount of silicon acceptable, a test is made under the usual working conditions of the plant and the shells that are slightly hardened at the point are analyzed. These will contain the lowest admissible silicon percentage

RULE FOR FIXING SILICON CONTENT

Experience has shown that to obtain a sufficiently strong metal, the empirical rule

$$T.\,C.+Si=4.50$$

must be satisfied. This is the maximum amount of silicon. For instance, if total carbon is 2.80 per cent then $Si=4.50-2.80=1.70$ per cent. If total carbon is 3.10 per cent then $Si=4.50-3.10=1.40$ per cent.

The amount of silicon must be kept between the limits of 1.40 and 1.70 per cent, the one corresponding to the minimum of silicon giving the maximum resistance permitted without having chilled castings or shells that are too hard and the other corresponding to the maximum of silicon, above which the castings would be too weak. Care must be exercised to have these figures refer to the final product and, therefore, provision must be made for silicon losses in the cupola.

In working between these limits, analyses made of the actual castings will show that the percentage of combined carbon will be more than 20 per cent of the total carbon necessary to give a satisfactory shell metal. If this figure is not attained, the physical test will not be satisfactory and the shells, when tested will be shattered into small splinters, similar to dust, whereas when 20 per cent or more of combined carbon is obtained, the splinters will be larger and will be more like those of forged steel shells.

Regarding the other elements, phosphorus and sulphur must be kept as low as possible, but it may be stated that satisfactory shells can be made with as much as 0.15 per cent phosphorus and 0.12 to 0.15 per cent sulphur. Phosphorus reduces the strength, but increases the fluidity. Sulphur is without much effect on the strength, but it reduces the fluidity and retains carbon in the combined form. Its action is counterbalanced by the manganese. Sulphur, however, has a tendency to produce blowholes when the metal is not poured at high temperatures and when the mold is not gated to prevent the entrance of air into the mold with the iron.

THE CHEMICAL COMPOSITION AND PHYSICAL TESTS

Maximum resistance to shock must not be sought, or the tensile strength will not be satisfactory. It must be remembered that a sample giving a high shock resistance will fail in the tensile test, and vice versa. A test bar, breaking under a high falling weight, undoubtedly reveals sluggish iron liable to produce blowholes and to chill at thin points. The tensile test probably will not be satisfactory. Under these circumstances,

reasonable limits must be fixed in both directions and the rules outlined will enable this result to be obtained.

If a high figure for the falling test and a low tensile test are obtained, silicon must be added.

If the tensile test is high and the falling test too low, carbon must be reduced.

Steel and ferrosilicon, or high silicon iron, are the two agents that will best serve the metallurgist, care being exercised to take into account possible variations in the initial metals used.

FREQUENT ANALYSES AND RAPID TESTS

It is helpful, of course, to analyze the initial and final products. Though it is difficult to rely entirely upon the regularity of the materials received, it must be admitted that analyses, properly made, are important. All materials should be analyzed, especially iron, scrap, coke, limestone, sand, core oil and finished castings. After a short time these analyses will provide a certain amount of fixed data which will enable the metallurgist to handle with a greater degree of certainty the factors that are liable to change from day to day. For instance, phosphorus, sulphur and manganese will remain about the same for each brand of iron, sulphur for each brand of coke, and limestone and sand do not vary much if received from one source. Silicon loss and carbon gain in the cupola will not change much if the same practice is followed every day.

Other factors, on the other hand, are liable to constant changes; these include silicon in pig metal, moisture in the sand, composition of the core oil, etc. Therefore, analyses must be made as frequently as seems necessary under the circumstances, always keeping in mind that *it is a practical impossibility to work only from analyses particularly on account of the irregularity of the materials.*

Either Keep's or a chill test should be made constantly to determine roughly if the amount of silicon is right. If not the iron may be pigged and a part of the loss recovered, or the iron can be improved by additions in the ladle, or changes in the subsequent cupola charges. It is the prevailing practice to add powdered ferrosilicon in the ladle when the iron is too hard.

It also may be necessary, when the product is too variable, to pig a certain amount of metal, for instance, to prepare a low carbon metal from hematite iron and a large percentage of steel to use instead of scrap. It this metal is analyzed it makes more certain obtaining a satisfactory final product. Some firms knowingly increase their amount of foundry scrap of known composition by making the risers much larger than is really necessary. These processes increase the regularity of the work, but at a heavy expense in time and money and they must only be resorted to when all other means have failed.

A useful, rapid test consists of taking a sample of metal every half hour and pouring it against a chill. The sample is plunged into water when set and is broken immediately. An experienced eye can tell quickly the depth of chill that gives the right metal for the needs of the foundry. This depth is not the same for all classes of shells; it must be less for small, or thin projectiles, than for heavy ones. I prefer this to another test recommended by the ordnance department, which consists of pouring cones into open sand molds from time to time, and after cooling the points are broken off for the purpose of ascertaining from the fracture if the metal is right.

OPERATION OF THE CUPOLA

The operation of the cupola is similar to that for ordinary work. However, the amount of coke used is somewhat more than the usual average, but not so much as might be imagined. It is generally from 12 to 15 per cent of the charges and this is essential on account of the necessity of having metal much hotter than is obtained usually, if sound castings are to be made. It must be borne in mind that a blowhole which would be unimportant in a machinery casting would not be passed in a shell. Also, it must be remembered that a certain amount of carbon is absorbed by the steel charged before it melts.

Some foundries are using up to 20 per cent coke, but the writer considers this bad practice, as satisfactory results are obtained with a smaller amount. However, in spite of the high price of coke, foundries must not be tempted to reduce its consumption to less than that necessary to obtain the best results. Good shells are obtained regularly when the temperature of the iron at the cupola spout is about 1,450 degrees C. and it must never be less than 1,250 degree C. when entering the mold. Unfortunately, there are few practical methods of readily measuring the temperature of a stream of iron.

RULES FOR CHARGING

In charging the cupola, the rules laid down by Richard Moldenke may be followed. However, it has been found that better results have been obtained by increasing both coke and iron charges by 50 to 100 per cent over what he recommends. That means that coke charges are 6 to 8 inches high and iron charges in proportion. Different methods are followed for charging limestone and variations in the amounts used also prevail. With the poor grade of coke now furnished in this country, containing from 16 to 18 per cent of ash, some foundries use up to 12 per cent limestone and add it to all charges, including the bed. This means that charging 12 per cent coke, as much limestone as coke is used. Other foundries use two and one-half times as much limestone as ash in the coke. Good results are obtained with 5 to 6 per cent of lime. Good limestone contains about 50 per cent lime.

The pig iron should be broken into small pieces, but it is still more important to use steel in small rather than large pieces, as the action of cementation which takes place before liquefaction takes some time and would not be completed if the pieces are too large.

Smelter Fumes

The attention of a visitor at one of the large copper or lead ore reduction works is often arrested by the tremendous quantity of molten slag that is continually being discharged from trains of slag cars and which, flowing down the sides of the slag dump, suggests lava flowing down the mountain side from a miniature volcano. The tailings from the concentrating mill form an even greater mass of waste material which, accumulating year after year, frequently builds up artificial mounds more than 100 feet high and covering many acres. Great improvements made in metallurgical processes in the last few years have made it possible to profitably rework this material at several plants.

The huge fume cloud emitted by the main stack of the smelter, although presenting a striking spectacle as it stretches for miles across the country, is not likely to suggest to the visitor the same possibilities of potential value as the enormous accumulations of waste mentioned. It is hard to realize that the weight of the gases leaving the smelter stack is frequently more than ten times as great as that of the slag that the plant produces, and perhaps three or four times as great as that of the tailings discharged from the concentrating plant.

Although the major part of this gas is air from which the oxygen has been partly removed in the various processes through which it has passed, the gas stream often contains other material that, if it could be collected in serviceable condition, would be worth a veritable king's ransom. The substances in the gas stream may be divided into two classes, namely, minute suspended particles of solid and liquid matter, the so-called dust and fume, which render the stack discharge visible to the eye, and the truly gaseous material which is by itself invisible. The suspended matter is composed of minute particles of ore and other substances from the furnace charge, which are mechanically carried out by the rapidly moving gases, and also of material that has been volatilized by the intense heat of the furnaces and subsequently condensed in the form of liquid or solid particles when the gases have somewhat cooled, just as atmospheric moisture in a warm moist wind from the south condenses into fog when striking colder currents from the north.

The suspended material in the gas stream from a copper smelter will contain in general not only copper but also lead, zinc, gold, silver, and any other substances associated with the copper in the ore. The value of these metallic constituents discharged with the gases by a large smelting plant may amount to several thousand dollars per day, and it is only within recent years that methods have been developed by which a part if not all of the suspended material can be removed from the gas stream and subjected to special processes for the recovery of the valuable metals.—*Year Book of the U. S. Bureau of Mines.*

Animal Camouflage

Dr. P. Chalmers Mitchell, F.R.S., Secretary of the Zoological Society of London, recently delivered the first lecture of his course on "Animal Camouflage."

The lecturer began by observing that in the animal world more brilliant colors and patterns were hidden than were seen. Animals dredged up from the depths of the sea were, in many cases, brilliantly colored and adorned with intricate patterns. Moreover, colors and patterns were even more conspicuous in the interiors of animals than in their exteriors, as a glimpse at a butchers' shop in pre-war times would show; and in support of the adage that beauty is skin deep, he suggested that if the chimpanzee and the orang, were flayed, what remained would be as beautiful as a human being similarly treated.

It was, of course, well known that some animals seem to make themselves as conspicuous as possible, *e. g.*, the bird of paradise or the cock pheasant. A favorite explanation of this is the "wedding dress" theory, viz., that the bird puts on his gayest clothes when he goes a courting; but Dr. Chalmers Mitchell inclined to the opinion that, as the hen sits on the eggs and looks after the young, it is important that she should remain as inconspicuous as possible, while the cock endeavors to distract attention from her to himself both by his gay garments and his singing. Other animals, again, like rattlesnakes, try to make themselves conspicuous for different reasons. A snake is a delicate creature, and its ribs, and even its back, are easily broken; and when it is not hunting it lies out in the open, where it will be distinctly seen, and advertises its dangerous presence in the hope that it may not be inadvertently molested.

In most cases animals try to conceal themselves, and one important way of doing so is by endeavoring to match their surroundings. The leaf insect, which is considered good to eat by numerous enemies, is a fine example of this. Another instance shown on the screen was the privet hawk moth. The moth, which flies at night, is dusky, but the caterpillar is bright green, and is hard to see on the leaves of its favorite food.

After describing animals which live in snowy regions, and which have either white coats all the year round, like the polar bear, or summer and winter suits, like arctic foxes, hares, and ermine, the lecturer passed on to spotted and striped animals. Few patterns could be more conspicuous than the spotted coat of the jaguar when seen in a museum or a menagerie; but a remarkable photograph brought out the fact that when in its natural surroundings of forest the beast becomes almost invisible. Similarly, even giraffes blend in with their natural surroundings to such an extent that at a little distance it is extremely difficult to detect them.—*English Mechanic.*

Experiments in Ray Collecting and Filtering for Microscopists

A writer in the *English Mechanic* relates the following experiments in making inexpensive ray collectors and filters that may be useful to amateur microscopists. He says:

"Passing by a restaurant last Friday, I looked in the window, and saw some bottles labelled, 'Vino Chianti'—not the wine, but the shape and color of the bottles attracted my eyes. They had long necks, with nearly globular bodies, and were of a curious green color. I went into the shop and asked for an empty one, and was fortunate enough to obtain one for 'tuppence.' When I got home I removed the plaited straw case and filled it with tap water. My idea was that its curious green color would make it a good light filter, and its globular shape a good ray collector. Nor was I disappointed. I lit the gas-lamp, placed the bottle in a glass receptacle to keep it upright, adjusted the burner so that it shone directly through the center of the globular body, and focussed it on to the mirror as if it were an ordinary bull's-eye condenser. The result was most pleasing and effective—almost startling. I tried several objectives, and finished up with my Baker's achromatic $\frac{1}{12}$-inch O. I. This is only, in ordinary times, a £5 lens, but it actually does all done by a $\frac{1}{16}$-inch alien fluorite I once used. The proof of its excellence may be guessed when I say that with a full solid cone, helped by the aid of my bottle-green light, it very neatly lined A. pellucida; and when I put in an eighth moon stop it showed what we must, I think, regard its moniliform structure. Did anyone ever before in microscopical experiments employ a wine-bottle to aid them? I could mention a lot of things I did, but this one must suffice. So encouraged, I thought I would go one better. At the local office of our gas company I was able to get for a shilling an almost perfect globe with only one aperture, and made of better glass than the bottle was, and perfectly transparent. With rain water I made a saturated solution of copper acetate, and placed a cover over the aperture. Very carefully I adjusted it, and as it was 6 inches in diameter, I cut a circular hole 2 inches in diameter, and used that as a diaphragm to the globe. Then I looked at a beautiful group of diatoms with a P. and L. $\frac{2}{3}$-inch achromatic. This time I called up all hands to come and look, and one remark made was, "Is it not a pretty sunlit field?" and so it was. Again I could say a lot, but I thought I would go another one better. This time I borrowed a small flask, such as analytical chemists use, made of excellent glass, with a perfectly globular body, and able to stand upright without any aid. This I filled with a mixture of ammonia, sulphate of copper, and distilled water, so arranging matters that the color of the mixture was neither too faint nor too dense. This is now being used on my afternoon collection of algæ. It is the most efficient of all three, and that is because the glass is free from defects. My next "stunt" is to get a transparent globe used for midget gaslamps, seal up the wider opening, and fill it with 160 grains of copper nitrate, 14 grains of chromic acid, and about 8 ounces of distilled water, and shall expect to receive equally good results if I can get a globe free from defects. These collecting lenses and light filters combined take little trouble to accurately adjust, but I wish some readers would try them and record their opinions of their capabilities.

How Big Timber Is Cut Up

At the Exposition of the National Railway Appliances Association, at Chicago, last winter, there was shown by the West Coast Lumbermen's Association a section of a big log of fir four feet in diameter, cut to illustrate how the sawmill man cuts timber of this kind to uitilize it to the best advantage. We are indebted to the *West Coast Lumberman* for the accompanying illustration, and for the following comment.

In government reports Douglas fir, which comprises 25 per cent of the remaining stand of merchantable timber in continental United States, has been termed "America's most useful wood." The log section sent to Chicago by the association was so manufactured as to illustrate this point. It illustrates the production of lumber for more than forty purposes from a single log.

The log was selected for grade but not for size. It constitutes a visual index of Douglas fir's great utility. In all the years of lumber and railway exhibits nothing like it has ever before been attempted.

When it was decided that the West Coast Lumbermen's Association should participate in this year's big eastern railway appliances show, instructions were given that the Western exhibit should be original, educational and attractive. C. J. Hogue, the association's district secretary for Oregon, developed the log section idea and submitted the problem to Frank H. Ransom, manager of the Eastern & Western Lumber Co. of Portland.

The originality of the scheme so enthused Mr. Ransom that he called J. W. Fowler, superintendent of the Eastern & Western mill, into consultation, and it was decided to cut a four-inch drum off the end of a 48-inch yellow fir log with a drag saw and then put the drum through a resaw which would permit the convenient reassembling of the various cuts for mounting back into the original log shape here illustrated.

Insofar as demonstrating the possibilities of the utility of the fir log is concerned, it was found that the result was just as practical as if the log section had been run through the head saw and then further manufactured as in general practice.

Of course every Douglas fir log would not be of a grade capable of developing all of the material represented in this particular cross-section—the log used being somewhat above the average in that respect.

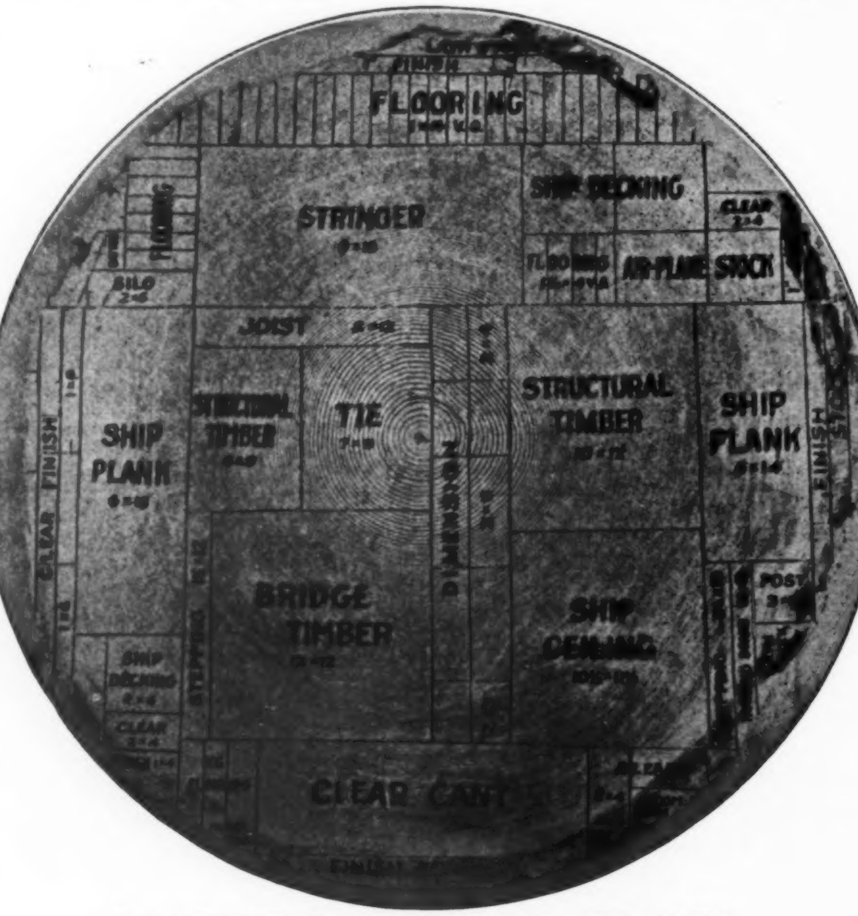
Conserving Mechanical Ability

The time is ripe for mechanical men in this country to get together and in some way draw the attention of the Government to the urgent necessity of exempting from active service the machine and tool designers, toolmakers, and gage-makers, who are proving more and more every day that it is part of their job to win this war. The proposition can be taken up in much the same way as the medical profession obtained its exemptions, for the mechanical men of the country are just as valuable in their line as the medical men are in theirs. Furthermore, if mechanical ingenuity and thought had not been applied to the medical profession it would not be in as advanced a stage as it is. No surgeon would attempt a capital operation with instruments of crude manufacture; neither could he use the X-ray, pulsometer, testing microscope, or any of his other instruments if it had not been for the toolmaker or designer whose ingenuity made it possible for these instruments to be manufactured in such a high state of perfection. There is little doubt that of the millions of articles manufactured today in this country, ninty-nine per cent were either invented or improved by mechanical men.

If this is true, which can easily be determined by an investigation, why is it that the Government should take such constructive men away from their work which has required years to learn and make destructive, non-producing men out of them? Is it of advantage to this country to reduce the high production and high standard of quality for which we are known throughout the world? For that is what we are doing when we draft into the army men trained to keep this production and quality at its present level.

It has been stated that in the first 5 per cent of the draft received at Camp Upton were twenty-five designers, six mechanical engineers and twenty-five or thirty mechanics such as toolmakers, gage-makers, machinists, etc. If each mechanical engineer is a graduate from a college having a four-year course, but without the practical experience, for the six men this will mean twenty-four years of preparation.

In order to become a full-fledged designer, a working knowledge of machine shop practice is essential. Assuming that the designer serves an apprenticeship of four years, and in addition has from six to twelve months' training in mechanical drawing and from two to three years on detail work, according to ability, the preparation of a designer requires about six to eight years; to be conservative, say five years. For the twenty-five designers this means 125 years of preparation. Machinists serve a four-year apprenticeship; toolmakers, who are graduate machinists, five to six years; gage-makers, five to seven years. As a result, considering five years as the average instruction period required by the mechanic, the time spent by these men preparing for their work is:



Cross-section of 48-inch fir log demonstrating the possibilities of utilizing the log to the best advantage

25 mechanics	125 years
25 designers	125 years
6 mechanical engineers	24 years
Total	274 years

This does not mean a staff of "dyed-in-the-wool" practical, experienced men, but men who will, after the war is over, help in the reconstruction period.

Under present methods of warfare in Europe it would appear that we might be able to use about two out of every four or five men if they all came back; but, assuming that we lose two out of five men, one being killed in battle and one maimed, the loss is:

10 mechanics	50 years
10 designers	50 years
2 mechanical engineers	8 years
Total	108 years

In other words, 108 years of mechanical skill is lost. Can you imagine what a staff of men like this in any plant in the United States could do to produce articles that are urgently needed? Such skilled men, working under an experienced engineer, could effect more essential results in a ten-hour day at a plant on government work than they could do in a month in the trenches. These figures do not include men who have had ten, twelve, or fifteen years practical experience, and there are some men at Yaphank who have had a number of years of experience in this line of work.

It is not the writer's intention to give the impression to men outside of the mechanical field that all mechanical men should be exempted. It is strongly urged that the Government mobilize all these producing men in a great army and send them throughout the country to plants where they will be able to do their best in speeding up the manufacture of the thousand and one articles necessary to the successful prosecution of the war; and when the reconstruction period comes, they will be in a position that will require no readjustment. France and England realize the great mistake they made in letting their mechanical men go to the front, and have had to come to this country for their supplies. If we make this same mistake, there is no source to which we can turn, and so we will have to take the consequences.

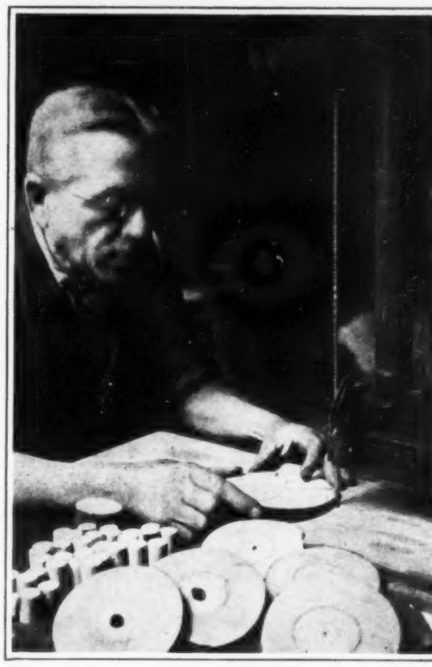
There are at present, to the writer's knowledge, about a dozen concerns around New York that are doing government work, but have only half enough men to get out the work, because of the scarcity of men. One firm in July, 1917, inserted advertisements for draftsmen in two New York papers for one week and only received twelve replies. Out of these twelve, about five applicants appeared promising, so letters were sent to these asking each to call. Four of the men called. One did not think he was able to handle the job, one man was capable, and the other two men were not experienced in that branch, but were willing to learn. So the result of one week's advertising was one capable man and two green hands. This firm pays its men well and the men in charge have good reputations in handling men, yet it is unable to obtain enough men. If this is true concerning conditions a short time ago, what will it be a little later?—A. H. J. in *Machinery*.

Crystal Growth and Solubility

The causes underlying the regularity of the growth of crystal and their resolubility, in other words, the determining factors in the equilibrium between a crystal and its own solution, are by no means understood. It is largely assumed that different crystal faces have different solubilities (P. Curie), and that there can only be equilibrium between the crystal and its solution, when the form of the crystal is such that the surface energy is a minimum (G. Wulff). A Ritzel has combined the two views, both of which, however, seem to lack sufficient experimental and theoretical basis. Rosicky, of Prague, showed in 1914 that the different crystal faces of rock salt, which has always been considered as typical and representative of the regular system of crystallography, behave differently with respect to certain etching agents, but not with respect to other agents (acids), which would be a very peculiar case of asymmetry. On the other hand, J. J. P. Valeton could not, in very careful experiments with potassium, alum and other salts, find any traces of different solubilities in different directions: he kept his solutions constant within ± 0.002 degrees C. and constant as to concentration for days, experimenting with crystals from 2 mm. up to 20 mm. He concludes that, in microscopic crystals, the surface energy has a measurable influence on the solubility, and that such crystals can only be in equilibrium with their solutions if their form correspond to the minimum of surface energy. That influence would hardly be appreciable in microscopic crystals, however, and it would indeed be difficult to understand how monoclinic and triclinic crystals, which are certainly not symmetrical, could be in equilibrium with their solutions if they had different solubilities in different axial directions. Yet it is generally believed that the big crystals of metals grow at the expense of the small ones, and the crowding of atoms in different planes, as disclosed by Röntgen-ray analysis, may help to clear up the difficulties.—*Engineering*.

An ordinary circular saw is used for cutting the elephant tusks into suitable pieces, but as the material is very hard the lower part of the saw is run in a pan of water to keep it cool.

Examples of the ivory worker's art. In the foreground a number of finished objects such as are made by the ivory worker of today; in the background is ivory in its original form. On the extreme left is a cylindrical section cut from the base of a large tusk. The two slabs are longitudinal cuts, and on the right is a small tusk which has not yet been worked.



After being cut up by the circular saw the blocks may be readily cut to special sizes and shapes by a band saw in very much the same manner in which wood is worked.

The ivory carver formerly did all of the work with small chisels, but now the larger part of it is done with a power cutter. Tools of various sizes are used, depending on the fineness of the work in hand.

This workman is blowing a large African war horn, made from an elephant tusk, that found its way into a shipment of ivory from Africa. In the background are seen patterns for numerous articles produced in this shop.

A delicate example of the ivory carver's art. Finishing off the horse's head for the knight in a set of ivory chessmen. This requires a most careful and delicate workmanship, and a very small cutting wheel is used.

Checkers are quickly made by a rapidly revolving tool that cuts them out of sections sawed from a tusk.

Dice are made by roughly sawing out cubes, which are then ground true and polished on an emery wheel.

Ivory can be readily turned, much like wood, but the operation is more delicate and requires sharp tools.

The Vanishing Art of Ivory Carving

In years gone by ivory was used for innumerable objects both of ornament and practical purposes, but owing to decreased supplies, change in fashions and the introduction of other materials it is now little seen, and has become almost a luxury. With its disappearance the old art of ivory carving has waned, in spite of the introduction of modern machine tools that facilitate its working and reduce its cost. [Photos copyright by Publishers Photo Service.]

The Manufacture of Tin Plate*

By T. Lewis Bailey, Ph.D., F.I.C.

TINPLATE consists of sheet iron, or more properly mild steel, which has been coated with a thin film of metallic tin, the main object of this being to protect the steel from oxidation (rusting) in a moist atmosphere.

One of the chief uses to which tinplate is put is for casing petroleum and some few years ago one-third of our export of tinplate went for this purpose; other extensive applications are for canning beef, fish, vegetables, fruit, etc., the manufacture of containing vessels for confectionery, tobacco, and so on.

The production in this country runs into very high figures and entails the use of over a million tons of steel yearly and something like 16,000 tons of tin.

The tinning of iron sheets on any scale dates from the early part of the 17th century and the early home of the industry appears to have been Saxony and Bohemia. In the latter part of the same century tinplate was made to some extent in England, though the industry did not flourish here until 1720, when works were established at Pontypool in Monmouthshire by Major John Hanbury; other works soon followed in the same county and the industry extended westward throughout the whole of South Wales. It is a curious fact that today this trade is almost confined to South Wales and Monmouthshire. The number of works in 1750 was four, in 1850 it had increased to 34, and 25 years later there were 75 works, since which date the actual number of works has not increased; present-day works, however, are on a much more extended scale, development in more recent times having been largely in the direction of increased output.

An excellently illustrated paper on modern tinplate manufacture was read by R. Beaumont Thomas in 1906 at a meeting of the Institution of Mechanical Engineers at Cardiff[1], and a Home Office Report was published in 1912,[2] but textbook literature deals almost entirely with the older, now historical, methods, and a general summary may be found useful.

The earliest methods of making tinplate were described by Reaumur in 1725. Iron bars, about one inch square, were hammered out into thin sheets, which were cut to the requisite sizes by hand shears, then scrubbed with sandstone and pickled in water, rendered acid by means of fermenting barley meal. The pickled plates after being cleaned with sand and well washed were coated with tin. The pickling process occupied a couple of days and was carried out in vats, placed in vaults in which large fires were kept burning; periodically the workmen engaged on the operation entered the vaults in order to turn the sheets in the liquor to ensure even pickling.

The tinning of the sheets was carried out as follows: They were first immersed in molten palm oil, whence they were transferred vertically to a bath of molten tin; a thorough brushing of the sheets with a hempen brush followed this, and then came immersion in a second bath of tin, the molten tin in this case being covered with a layer of tallow. Excess of tin was removed by immersion in a bath of molten grease, after which the tinned sheets were cleaned and polished by hand with sawdust and moss. An excellent article was produced, with a heavier coating than is usual at the present time, when cost and competition are factors of such importance.

Present-day tinplate processes are of a totally different order.

The steel works deliver rolled bars, appropriately low in carbon (about 0.1%), to the tinplate manufacturer: these bars are from 6 to 10 inches in width and from ⅜ to ⅞ inch thick. The operations may be summarized as follows: details of general knowledge only may be given, of course.

(1) The bars are cut by means of bar-shears into desired lengths, usually about 20 inches.

(2) The cut bars are heated in the mill-furnaces and are rolled hot through two sets of rolls (roughing and finishing rolls). Sheet rolling was first introduced in 1728. According to present practice there are usually five separate heatings and rollings necessary to produce the requisite gage of sheet.

After two heats the thickness of the sheets produced is under one-tenth of an inch; to ensure satisfactory rolling the sheets are doubled; doubling follows also the third heating and the fourth heating, so that after the fifth heating and rolling each sheet consists of eight layers. By the employment of such methods a considerable output of thin sheet is attained in a short time. As an example of the results of rolling, a ⅝-inch bar will be transformed into a sheet of eight layers, each layer having a thickness of little over a hundredth of an inch.

Another method of rolling (so-called matching practice) common in America, consists in putting two pieces together after a first rolling; first doubling thus gives four layers and second doubling eight layers.

Occasionally in matching practice three plates are used, in which case a first doubling gives six layers and the next twelve.

(3) The rolled "eights" are sheared by means of a plate shearing machine into three portions, which are trimmed, and thus from an original bar 20 in.×8 in.× ⅝ in. there will be produced, for example, 24 sheets, each 14 in.×20 in.

(4) Owing to the repeated heating, doubling, and rolling there is considerable adherence of the individual sheets and the operation known as "opening" is necessary; this is effected by starting separation at one corner and then tearing the sheets apart.

(5) So-called black pickling now follows, the sheets being immersed in dilute sulphuric acid, heated by steam. The object is to remove from the surface of the sheets the oxide scale, which has formed during repeated heating. In this operation the sheets are packed loosely into a carrier, which depends from one arm of the pickling machine. This is rotated to a point above the pickling vat, then lowered so that the sheets enter the acid, and an up-and-down motion is continued during the period of immersion. The pickling occupies a matter of a few minutes only and, when complete, raising of the carrier and further rotation takes the carrier with its load to a washing tank plentifully supplied with running water. At the same time a second arm of the machine has brought a fresh batch of sheets to the acid bath.

For pickling purposes hydrochloric acid took the place of barley meal in 1760, and this in turn began to give place to sulphuric acid in 1806. Sulphuric acid is now universally employed in the tinplate trade proper. Waste "pickle" still contains free sulphuric acid; after treatment with iron scrap, ferrous sulphate (copperas) is recovered by recrystallization.

Proposals have recently been made in the United States to pickle electrolytically,[3] the sheets forming the cathode in an acid solution.

(6) Annealing of the sheets is now necessary (black annealing). For this purpose the sheets are stacked horizontally on cast-steel or wrought-iron stands and covered with boxes of like material, sand luting being provided between cover and base. The annealing furnaces are either coal fired or gas fired and the operation occupies from 10 to 12 hours. The product is now what is generally known as "blackplate."

(7) Now comes a further rolling (cold rolling); the sheets are rapidly passed separately through three or sometimes four successive trains of rolls, whereby they attain considerable smoothness and polish.

(8) A second annealing (white annealing) follows, occupying about seven hours.

(9) A second pickling in sulphuric acid is necessary, but this is of short duration and after thorough washing in water the sheets are ready for to receive their coating of tin.

(10) Tinning. Hand labor is dispensed with as far as possible in all the operations hitherto described, and this applies also to the tinning operations; the old arduous methods have been superseded by the introduction gradually since 1866 of mechanical devices. The sheets are fed by hand into the cast-iron tinning pot and are removed by hand ready for cleaning (though a device has even been introduced for transferring them mechanically from the tinning pot to the cleaning machines).

The tinning pots are of two varieties, a double horizontal type and a vertical type. In either case the sheets separately enter the tinning pot through a layer of zinc chloride solution, floating on the surface of the molten tin. The pots usually contain 3 or 4 tons of tin, kept molten by a coal fire under the pot. A succession of pairs of revolving rolls and guides at various positions guide the sheets on their way through the tin, downwards and then upwards until they emerge from the tin and pass vertically through a column of molten palm oil. During their passage through this latter a pair of rolls removes excess tin.

(11) The tinned sheets are now passed on to a cleaning machine, which carries them twice through a mass of bran or of "pink meal" (consisting largely of gypsum, mixed sometimes with sawdust) and this machine delivers them to a battery of dusting rolls covered with sheepskin, each alternate pair of rolls running at different speed to ensure polishing action on the surface of the now finished sheets.

The development of the tinplate trade has been essentially along mechanical lines but throughout the operations described there are problems which would well repay chemical investigation. At the end of the process, moreover, there exists a problem which is peculiarly chemical; it is that of the treatment of the dross, which collects on the surface of the tin in the tinning pot, a material technically known as tin scruff. This is periodically skimmed off and put on one side for treatment. It is a very complex mixture, containing 50%, or even more, of metallic tin, mixed with chlorides, of tin and zinc, iron and sulphur compounds and palm oil. It is quite impossible satisfactorily to sample the material for sale to tin smelters and consequently it is heated in reverberatory furnaces at the tinplate works with production of a certain amount of metallic tin and a considerable oxidized residue containing tin, iron, and zinc, but now in a condition to admit of sampling for sale purposes. This operation, which should be a liquation process purely, is frequently carried out at abnormally high temperatures and causes the evolution of very dense fumes, containing considerable quantities of oxides and chlorides of tin and zinc, free hydrochloric acid, and products of destructive distillation of palm-oil. Such fumes, at one time evolved from short 20-ft. chimneys, were a source of trouble; they were very irritating and were, moreover, destructive of some types of vegetation in the neighborhood of the works—the thick fumes traveled for considerable distances in the form of a thick white fog. Works dealing with the smelting or liquation of scruff were included as a class in the provisions of the Alkali, etc., Works Regulation Act, 1906, and investigations were carried out with a view to mitigating the nuisance due to the evolved fumes, and this resolved itself essentially into devising simple means for the reduction to satisfactory limits (¼ grain per cubic foot) of the hydrochloric acid contained in the gases passing from the chimneys[4]. The problem of ascertaining the best possible method of treating tin scruff for the complete recovery of its valuable constituents could not receive attention, but it will be of interest to record some of the results obtained during the working out of the problem as it presented itself from an Alkali Act standpoint.

The method employed in "scruff-melting" usually consisted in charging a couple of hundredweight of more of scruff on to the hearth of the heated furnace, allowing it to remain for a quarter of an hour until thoroughly heated to softening point, then stirring it, allowing it once more to remain dormant for a few minutes, then rabbling well for short spells during the remainder of the operation, until metallic tin practically ceased to run from the furnace. As it was usual to mix together all skimmings, those containing much zinc chloride and those containing little, it is evident that there were great possibilities of loss occurring mechanically and chemically during the furnacing operations; in most cases no dust-depositing flues were in use and the chimneys were very short; where flues of any length did exist they were frequently of small cross-section and led to a high boiler-chimney, not dampered off at the chimney end of the flue—a furnace damper only, naturally, had little effect on the depositions of fume in such flues.

The first modification introduced was to keep "flux skimmings" (*i. e.*, those especially rich in zinc chloride) separate from the scruff proper and to wash these thoroughly in running water heated by steam. This precaution had the effect of considerably reducing the amount of fume evolved and at the same time lower temperatures could be used for liquation and better yields obtained.

From many estimations made at different works, it was shown that, with flux skimmings present in the charge, the chlorides in the chimney gases were equivalent to 2 grains of hydrochloric acid per cubic foot, whereas when flux skimmings were kept out the chlorides in the chimney gases were reduced to less than 1 grain per cubic foot in terms of hydrochloric acid; when flux skimmings were present in the charge 2½ grains of SnO_2 per cubic foot was present in the chimney gases, but if flux skimmings were kept separate, the escape of Sn_2 was less than ¾ grain per cubic foot.

The second step was the introduction of depositing flux for the purpose of retaining as much oxide of tin as possible, and at the end of the flues was built a simple type of wash-tower, in which hydrochloric acid was to be absorbed by water. All forms of tower packing proved impracticable: even pigeon-hole brickwork quickly became obstructed with thick greasy deposits that could not be removed by water. Towers with sloping shelves proved satisfactory from an absorption point of view, but breakages of the shelves were frequent, and ultimately unpacked brick towers were adopted, and to these water was supplied in the form of a shower from perforated plates, placed on the top of the towers. Two towers, each 9 feet high and 4 feet square, working in series, proved reasonably satisfactory for the purpose of removing hydrochloric acid from the gases. As a result of the various alterations adopted in the process the free hydrochloric acid was gradually reduced, after several years of patient work, from an average of 0.8 grain per

Journal of the Society of Chemical Industry.

[1] Proc. Inst. Mech. Eng., 1906, 499.

[2] Report on the Conditions of Employment in the Manufacture of Tinplates, with special reference to the Process of Tinning; by Edgar L. Collis and J. Hilditch. (Cd. 6394.)

[3] Thompson and Mahlman, this *Jour Soc. Chem. Ind.*, 1917, 1097.

[4] Annual Reports on Alkali, etc., Works, 1908 to 1913, the portions relating to Districts VI and VIA.

cubic foot of chimney gases to 0.086, a figure well below the limit prescribed as the maximum permissible. The wash-towers have, moreover, had a further beneficial effect, in that they reduced the total acidity of the chimney gases (in terms of SO) from 1.55 grain per cubic foot to 0.48 grain. The extent to which it was possible to reduce the loss of oxide of tin depended chiefly on the depositing flues that were built: where reasonably large flues were put in, with a control damper at the chimney end of the flue, good recovery of flue dust rich in SnO_2 resulted, and this proved a valuable product, of course.

In 1915, at the desire of the Chief Inspector, special investigations were carried out on one plant, where a depositing flue and wash-towers had been installed. It was desired to ascertain the efficiency of both flue and wash-towers. Full details of the investigations, which extended over several days, are given in the Alkali Report for that year.[5] The depositing flue in the case in question was 125 feet in length and 2 feet square in section; the speed of the gases ascertained was from 4 to 5 feet per second (cold), furnace temperatures during the operation was 800° to 900° C., the mean temperature of the gases entering the flue was 440° C., ranging between 650° C. and 350° C., and this became reduced to 240° C. by the time the wash-tower was reached. The wash-tower contained two outer compartments, each 9 feet high and 4 feet square, and one intermediate compartment 9 feet high and 4 feet by 9 inches section, each compartment was provided with a water shower, the gases ascended in the two larger compartments and descended through the smaller intermediate compartment: the wash-tower cooled the gases from 240° C. to 105° C.

Under such conditions 82% of the hydrochloric acid was removed and 42% of the oxide of tin leaving the furnace was condensed. The amount of tin passing away entirely from the system still constituted 10% of the total tin charged into the furnace. The furnacing operation includes long spells of rabbling of the charge and at such times there is admission of much air, so that an oxidizing atmosphere prevails, by no means an ideal condition in a process of this kind. A furnace temperature of 900° C. must be considered high (considerably higher temperatures have been met with) and it was clearly indicated in the course of the investigations that with lower working temperatures there is improvement in the results, but the existing system itself might well be improved by the adoption of a larger condensing area, better regulation of draught, and by contact with water even in the earlier part of the system.

A method of scruff treatment that proved particularly suitable for small works consisted in washing the whole of the tin scruff for some days in water kept at somewhere near boiling point by means of steam, dissolved zinc chloride, etc., being continuously removed by a small continuous supply of water to the washing tank. The washed scruff lends itself to furnace treatment at a very low temperature, yields are good, and there is practically no evolution of either hydrochloric acid or tin compounds; depositing flues and wash-towers thus become unnecessary.

But of course there is in none of these methods any attempt at recovery of by-products with the exception of oxide of tin. What one would like to see investigated is a self-contained method of complete scruff treatment on chemical lines, but, until some sort of chemical control obtains in the tinplate works, there is little likelihood of this and other problems being taken sufficiently seriously.

During the past few years three patents have been taken out in connection with the treatment of tin scruff. In 1909, H. J. Bailey[6] patented a combined smelting and lixiviating process and in the same year James Stephens[7] patented a separation and washing method, in which recovery of dissolved metallic compounds was the object in view.

In 1912, S. B. Bowen[8] brought out a different type of process: a preliminary heating of the scruff in a closed vessel by waste heat from the scruff furnace proper brought about liquation of a proportion of the metallic tin and at the same time chloride of tin and oily matter distilled and were condensed in small cooling towers: the liquated residue was then washed in water and furnaced for further recovery of tin.

But progress has not been made on these lines; with the existing lack of chemical control it can scarcely be looked for.

[5]Annual Report on Alkali, etc., Works, 1915, pp. 48 to61: E. Linder and T. L. Bailey, this J., 1916, 1012.

[6]Annual Report on Alakali, etc., Works, 9019, p. 108. Eng. Pat. 17,474 of 1909; this J., 1910, 1063.

[7]Annual Report on Alakli, etc., Works, 1909, p. 108. Eng. Pat. 17,345 of 1909; this J., 1910, 497.

[8]Annual Report on Alkali, etc., Works, 1912, p. 108. Eng. Pat. 7945 of 1912; this J., 1913, 493.

The Sunflower

By C. D. Mell

One of the many effects of the war in its relation to agriculture has been the increase in the use and price of the little-known and apparently unimportant crops. Prominent among these is the sunflower. The seed of this plant formerly came into this country entirely from Russia at a cost of about three cents a pound, but since the war a considerable amount has been grown in this country. A well-known seed house in the middle west states that sunflower is being grown quite extensively in parts of Missouri and Arkansas and that the seed has advanced in price from three cents per pound in 1914 to about six cents at the present time.

The increased demand and use of sunflower seed in this country as well as abroad and its consequent rise in price during the past few years has resulted in a number of inquiries regarding the crop. A brief popular discussion of the more noteworthy uses may be of interest to a number of readers. The object of this is, therefore, to describe briefly the general characteristics of the plant, the uses to which the different parts of the plant are put, and its possibilities as an agricultural crop in the United States.

The sunflower is one of our most familiar plants and is closely related to the Jerusalem artichoke. The Latin generic name is *Helianthus*, which is derived from *helios*, the sun and from *anthos*, a flower. The different common names of this plant in all countries have relation to the sun. There are two good reasons why this plant is called sunflower: One is because of the resemblance of the large flowers to the sun; the other reason is the tendency of the flower heads to turn in a stronger degree than any other plant toward the sun. From these circumstances the French call it turnesol, the Italians girasole, and the English turnsol.

The flower heads are composed of many small tubular flowers arranged compactly on a flattish disk; those in the outer row have long ligutate corallas forming the rays of the composite flower. These circular flower heads are often from one to two feet in diameter. The plant itself is large, often attaining the height of from six to twenty feet with the flowers coming from the terminal buds. The best cultivated varieties, such as mammoth Russia or big black Russian, develop but one flower head. The wild forms and inferior varieties often develop from two to six or more small heads with relatively small seeds.

It is said that the sunflower originally came from Central America and it is believed that it was cultivated by the Indians in Yucatan, Mexico, and Peru long before the discovery of America. It was brought from Mexico to Spain in the Sixteenth Century and from there it soon spread over all the countries of Europe and greater part of Asia. It appears that its best development is attained in western and southern Russia. While this plant was introduced from Mexico into the United States and now grows spontaneously almost everywhere in this country, it was not until recent years that a cultivated variety was introduced. There are a number of good varieties now under cultivation, but the black-seeded variety is doubtless the most productive kind. There is a well-defined Manchurian variety; another kind is now grown successfully in Spain. There is also a small-seeded variety growing in America. The Russian black-seeded variety is highly prized on account of its high yield of seed per acre. It is said that these seeds yield between 50 and 60 per cent of the best grade of oil.

The best results in sunflower cultivation in America are obtained from a well-tilled soil with not too much clay in its composition; it should be well ploughed in the autumn and harrowed in the spring. The seeds should be planted in April or May. Various methods of planting and spacing are being recommended in different countries. It is best to plant in rows running north and south, the seeds to be placed 9 inches apart in rows 30 inches apart. If the seeds are planted by means of a carefully regulated drill such as is used in planting corn not over five pounds of seed are required to plant an acre. It is of interest to note here that the plant assimilates a large quantity of potash and, therefore, it must not be planted in the same soil the second year or a fail crop will result.

The growing of sunflower in America may be said to have hardly commenced. There are at present only a few states interested in growing the seed on a commercial scale. Statistics as to the acreage now under sunflower cultivation are not available. It is safe to say, however, that Missouri and Arkansas take the lead in this new industry in America. One grower in New Madrid, Mo., had 600 acres planted to sunflower in 1915; another had 400 acres near Portageville, and several other growers in the State had 100 each. One man in Arkansas planted the same year 100 acres. Considerable quantities of this seed are produced annually in Ohio, Indiana and Illinois, where the soil and climatic conditions are favorable for the successful development. The industry is beyond the experiment stage and any intelligent farmer who wants to diversify his crops can confidently undertake to raise sunflower and find a ready sale for his crop. It forms one of the well-known crops in Spain, France, Germany, Italy, Russia, Egypt, India, Manchuria and Japan.

Growers will experience no difficulty in disposing of their sunflower seeds for which there is a great variety of uses. The average acre will produce about 50 bushels of merchantable seeds and each bushel yields approximately one gallon of oil for which there is a whole series of important uses. There is now a growing demand for vegetable oils of all kinds and sunflower oil ranks high in the estimation of buyers of this class of manufactured plant products. A number of mills in the United States are prepared to express the oil. The price now for good seed is around six cents a pound and for this the grower can afford to devote a little of his time and attention to the cultivation of this new crop.

The cold oil pressed from the seeds is of a citron-yellow, sweet tasting oil, considered equal to olive or almond oil for table use. The resulting oil cake when warm pressed, yields a less valuable oil which is used largely for technical purposes, such as soap making, candle-making, and in the art of wool dressing. As a drying oil it is equal to linseed and is unrivalled as a lubricant. The residue after the oil is expressed forms an important cattle food. The oil cake is relished by sheep, pigs, pigeons, rabbits and poultry. It is said that cows, fed on sunflower seed oil cake mixed with bran will have an increased flow of good, rich milk. Feeding fowls on bruised sunflower seed is known to increase their laying power. It may be of interest to add that the seeds of the large-seeded varieties are much liked as a cheap dainty or a light refreshment by the poor Russians, and are sold in the street as are chestnuts in this country. When the seeds are roasted in the same manner as coffee they make an agreeable drink which may be used as a substitute for this article.

Every part of the sunflower plant may be utilized for some economic purpose. The leaves form a cattle food and the stems contain a fiber which may be used successfully in making paper. The pith of the sunflower stalk is the lightest substance known; its specific gravity is 0.028, while that of elder is 0.09 and of cork 0.24. The discovery of the extreme lightness of the pith of the stalk has essentially increased the commercial value of the plant. This light cellular substance is now carefully removed from the stalks and applied to a good many important uses. One of its chief uses is the making of the life saving appliances. Cork with a buoyancy of 1 to 5 and reindeer's hair with one of 1 to 10 have been used; the pith of the sunflower has a buoyancy of 1 to 35. The latter can be used advantageously in the construction of boats and life perservers. A sufficient quantity can be worn on the person without any inconvenience, which will insure perfect safety in case of immersion. The pith of the larger sunflower stalks is used extensively as a substitute for other materials formerly employed in making moxas for cauterizing purposes.

Transmission of Coke Oven Gas in Silesia

Since 1911 coke oven gas has been supplied from the coking plant near the Julius Colliery to Waldenburg and other places in Silesia, and the transmission and distribution lines have considerably been extended of late. Two short lines, about two miles long each, start from the colliery, the one to Waldenburg, the other to the gas-holder and general gas-meter stations at Altwasser; the mains have diameters of 200 mm. and 150 mm. The soil on the latter line is so much subjected to subsidences that it was not considered advisable to bury that section of the line in the ground; staging was first considered, but finally the line was laid in the ground. The line consists of steel pipe sections, 10m. or 12m. in length, and in the endangered ground the ends of the sections (Mannesmann pipes in this part), were fitted into curved sleeves; in some cases the pipe was pulled 400 mm. out of its sleeve, the subsidence of the ground amounting to quite one m. in the course of a year. The supply of gas was only in one case interrupted for more than 3 hours, however; the gas losses in the pipe system range from 2 per cent to 8 per cent; they are generally highest in the beginning of the summer (*Journal für Gasbeleuchtung*, October 27, 1917). In the gasholder the pressure is high, but in the distributing pipes it is 175 mm., 150 mm. or 80 mm. The coke oven gas having a higher density than the coal gas formerly used for illumination, the gas pressure had to be adapted to the burners. Some of the high pressure mains are more than 40 km. in length. The gas supply had, by 1916, increased to 5,000,000 cub. m. per year, but the industrial use of gas in large works was only developing.—*Engineering.*

The Sun's Position and Rotation

Facts Bearing on Its Past and Future Positions in the Universe

By Frederic R. Honey, Ph.B., Trinity College

A KNOWLEDGE of the place of the sun in the "universe of suns," and of the direction and velocity of its motion, suggests speculations upon its past and future positions in the universe. Whence has it come? And whither is it going? These questions involve a consideration of the magnitude of the universe which encloses the sun's vast orbit, and the further profound enquiry as to whether space is limited or unlimited.

By the latest determinations the sun, accompanied by the planets and their satellites, has at the present time a motion of approximately four hundred million miles a year, *i. e.*, more than twice the diameter of the earth's orbit; and the apex of the sun's way, or the point in the heavens toward which the sun is moving, is within a few degrees of Vega in the constellation Lyra.

While this determination is only approximate the point to which the sun's axis is directed, and the period of its rotation are well defined. If the axis be produced to the celestial sphere it would pierce it very nearly midway between Vega and Polaris.

Fig. 1 represents a portion of the celestial sphere—a vast hemisphere—in comparison with which the whole solar system would be reduced to a mere point. Its center is labelled S (the sun) and E (the earth); and the directions of their axes are shown by arrows. The angle which the earth's axis forms with the ecliptic (66° 33′) is shown in its true value; and the sun's axis, which forms with the ecliptic an angle of 83°, is in projection. The circle of longitude is in the plane of the ecliptic; and the right ascension circle, or celestial equator, forms with that plane an angle of 23° 27′. The distances of the stars are so great that, for the purpose of the present illustration, they may be considered to be situated on the surface of the same sphere as seen from the earth. The right ascension of Vega is 18h. 34m. and its declination 38° 42′; and the right ascension and declination of Polaris are respectively 1h. 30.7 m. and 88° 52′. The sun's axis is directed to a point whose right ascension is 18h. 44m. and declination is 64°. The approximate direction of the solar apex is represented by arrows. The right ascension is 18 h. and declination 34°.

Fig. 2 is a projection of the northern hemisphere, the latitude circle of New York city (lat.=ϕ), the north and south horizons, the direction of the zenith, and the elevation (ϕ) of the celestial pole above the horizon. The direction of the latter is parallel to the earth's axis, and practically coincides with that of the celestial sphere (see Fig. 1). In Fig. 1 Vega is approaching the meridian. The apparent direction of motion of the celestial sphere, as seen from the earth, is opposite that of the earth and is represented by the arrow *a*. If this page be reversed and held to the light, the arrows will indicate the actual direction of motion of the observer, and the apparent direction of motion of the stars looking south. In Fig. 2 Vega is on the meridian, and is nearly 2° south of the zenith.

Fig. 3. The drawing should be moved into positions where the dates may be read without turning the head. It shows the apparent positions of the sun's axis and equator relative to the plane of the ecliptic and to the north and south line, *i. e.*, the axis of the celestial sphere. The latter may easily be visualized by looking in the direction of the celestial pole which is near Polaris. It should be noted that this statement applies to any point on the earth's surface.

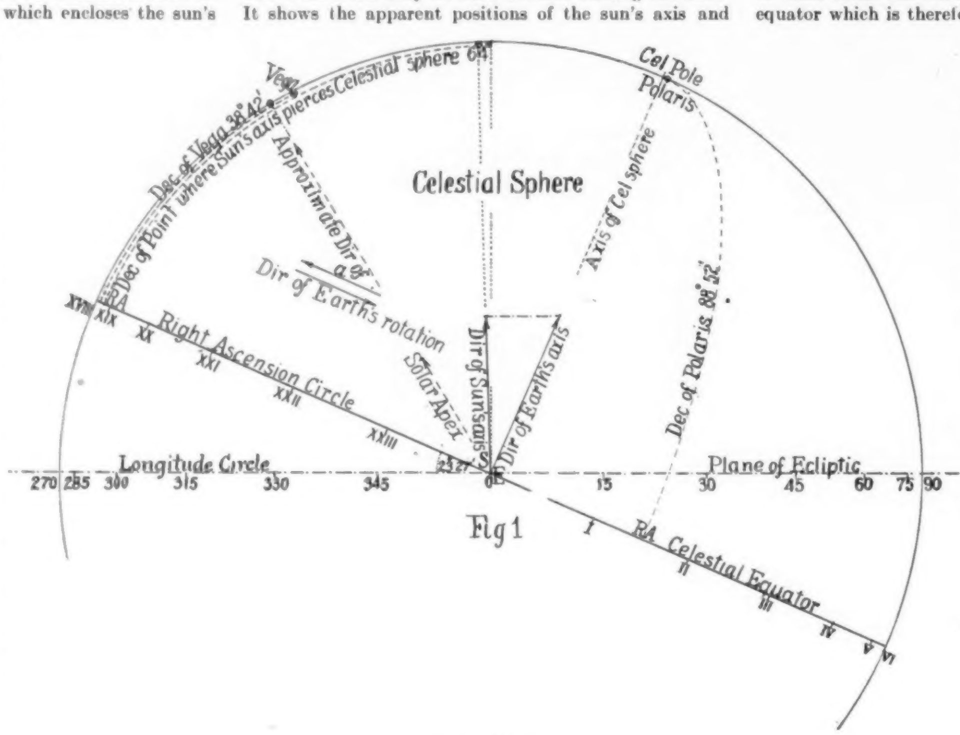


Fig 1

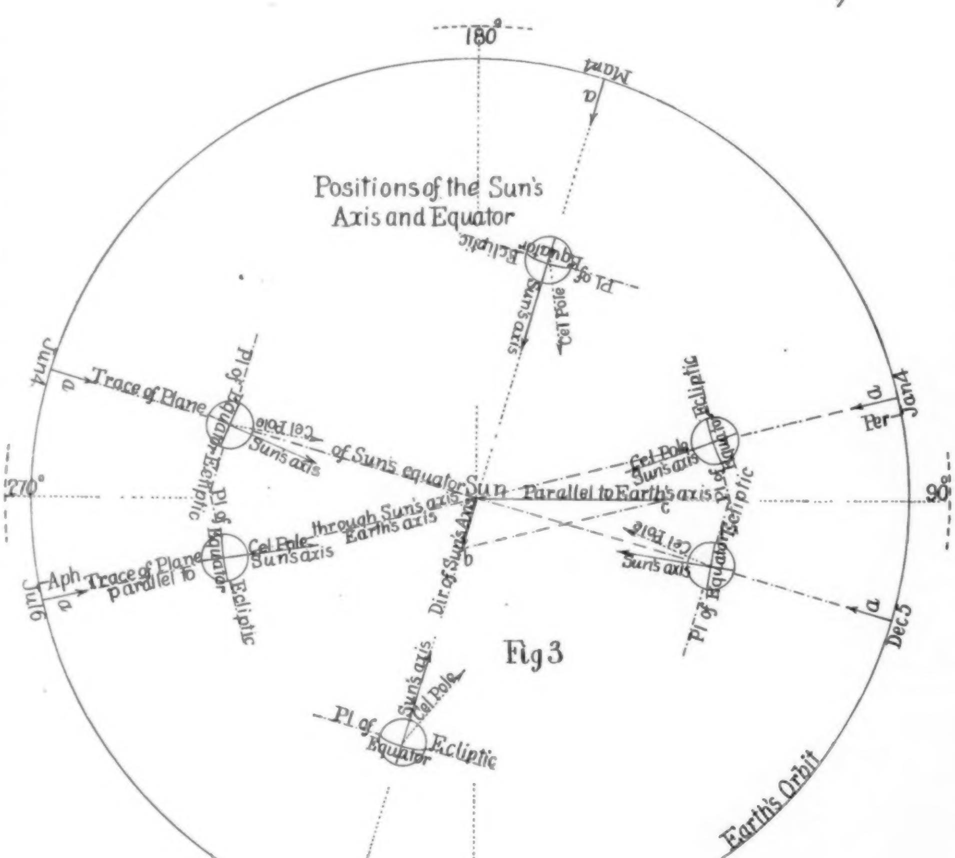


Fig 3

The plane of the sun's equator forms with the plane of the ecliptic an angle of 7°, and its trace on that plane intersects the earth's orbit at opposite points which the earth reaches on June 4th and December 5th. At each of these dates the observer is in the plane of the sun's equator which is therefore represented by a straight line.

If a line be drawn through the sun perpendicular to the trace of the plane of the equator, it will intersect the orbit at opposite points which the earth reaches on March 4th and September 6th. At these dates the sun's axis is projected perpendicularly to the ecliptic, and the equator is projected in an ellipse, the visible half of which is above the center on March 4th, and below on September 6th.

If a plane be passed through the sun's axis parallel to the earth's axis its trace will intersect the orbit at points which the earth reaches on January 4th and July 6th near perihelion and aphelion. At these dates the sun's axis produced apparently coincides with the axis of the celestial sphere, *i. e.*, it points to the pole of the heavens. The trace of this plane is found as follows: Through the sun's center draw o c parallel to the projection of the earth's axis on the plane of the ecliptic. The points c and b are assumed on this line and on the sun's axis respectively at equal distances from the ecliptic. The line b c is parallel to the trace of the required plane. Fig. 4 shows the details of the construction. The line o c is the projection of o c′ which forms with the ecliptic an angle of 66° 33′; and o b is the projection of o b′ which is inclined at an angle of 83°. Making bb′=cc′, the points b and c are equidistant from the ecliptic; b c is therefore parallel to its plane.

Make c″C=b″B equal to cc′=bb′. The arrows which are projected on the ecliptic at o b and o c are at these dates represented by the same line as seen in the direction of the arrows a, and are lettered o B and o C. By similar constructions the apparent positions of the axis and equator for any date may be found.

THE SUN'S ROTATION PERIOD

The rotation period is determined by observations of sun spots which are generally limited to zones between 6° and 35° on each side of the sun's equator, and which, owing to the nature of the photosphere, move at different velocities. A sun spot is an irregular opening in the photosphere. If it remains long enough on the surface it disappears at one limb and, after an interval of time, reappears at the other limb. It appears as a narrow opening which gradually widens as it approaches the sun's central meridian, and then diminishes in width until it disappears. The result of a large number of observations gives on the average the apparent or synodic period which is 27.23 days. But this is not the actual or sidereal period. During the interval

of the sun's rotation the earth moves to another position in its orbit. Let *a* (Fig. 5) represent the earth's position, and *s* a spot on the sun's central meridian. After one rotation the spot returns to *s*. But during the interval the earth moves to *b*, and the sun makes a fraction of a rotation while the earth moves to *c* when the spot again appears on the central meridian at *s'*. The

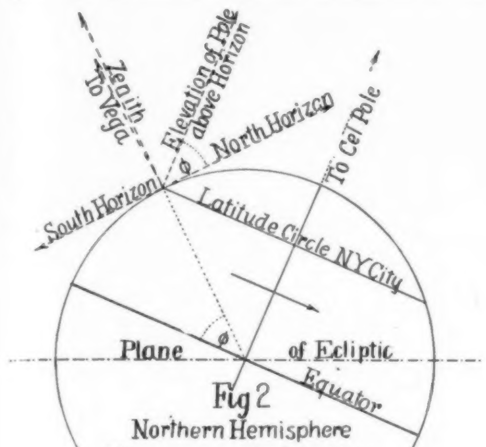


Fig 2

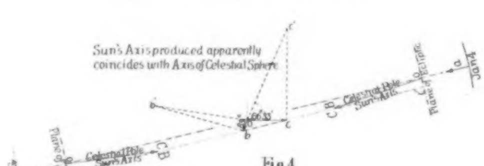


Fig 4

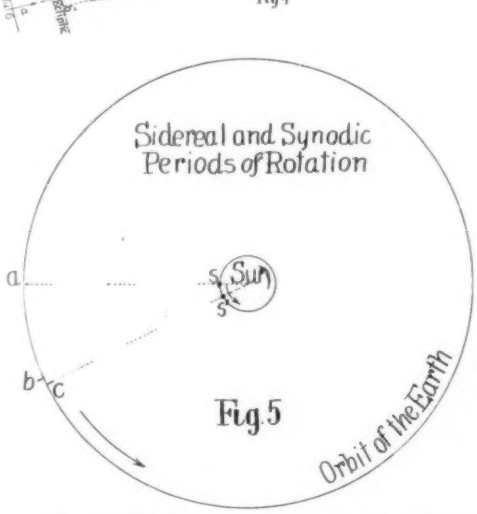


Fig 5

synodic period is therefore equal to the sidereal period increased by the interval of time during which the spot moves from *s* to *s'*. Let x = the sidereal period. The sun therefore makes $\frac{1}{x}$ of a rotation each day. The earth makes $\frac{1}{365.24}$ of a revolution daily. In 27.23 days the sun makes one rotation and a fraction which is expressed as $\frac{27.23}{x}$ of a rotation; i. e., $\frac{27.23}{x} = 1 + \frac{27.23}{365.24}$. From this equation x = 25.34 days which is the sidereal or actual period of the sun's rotation.

The Constituents of Portlant Cement*

As a result of investigations by the Bureau of Standards on the constituents of Portland cement the following conclusions were arrived at:

At early periods the constituents of Portland cement of normal composition and manufacture, in the order of their strength-conferring properties, are: Tricalcium silicate, tricalcium aluminate, and dicalcium silicate.

At periods beyond 28 days the dicalcium silicate gains sufficient strength to place it almost on an equality with the tricalcium silicate.

Tricalcium aluminate containing 10 per cent plaster gains practically no strength after the first period at which it was tested; that is, 24 hours.

Tricalcium silicate of the purity used in this investigation (90 per cent 3 $CaO.SiO_2$ in one case and 95 per cent in the other) has all the important properties of Portland cement, especially those of the "rate of setting" and strength developed.

*Technologic Paper No. 78 on Properties of the Calcium Silicates and Calcium Aluminate Occurring in Normal Portland Cement, by P. H. Bates, Chemist and A. A. Klein, Asst. Physicist.

Dicalcium silicate, such as used in this investigation, sets too slowly and attains strength too slowly to be of any commercial value when used alone.

Tricalcium aluminate alone, as used in this investigation, sets too rapidly and attains too little strength to be of any commercial value as a hydraulic cementing material.

Tricalcium aluminate, when used to replace about 19 per cent of the dicalcium silicate (which is approximately the amount of aluminate present in Portland cement), adds somewhat to the strength of the latter at the later periods. This mixture when used with the addition of 3 per cent of plaster gives lower strengths than the silicate alone, as neat test pieces, but as a 1:3 mortar the strengths are higher than any of the dicalcium silicate mixtures not containing the tricalcium silicate.

Tricalcium aluminate, when used to replace about 19 per cent of tricalcium silicate, did not add to the strength of the latter, showing rather a slight tendency to decrease it. The addition of 3 per cent of plaster gave higher early strengths but lower later ones.

Tricalcium aluminate, when used to replace about 19 per cent of a mixture of equal parts dicalcium and tricalcium silicate, increased the strength at 24 hours and 7 days, but decreased it at the later periods. The addition of 3 per cent of plaster increased the strength at all periods.

Plaster of Paris, when added to any of the compounds or mixtures of those studied, generally increase their strength. This effect is more marked at the early periods.

The amount of water of hydration of any of the compounds at any period is not a measure of the strength developed, as the dicalcium silicate at one year with 5.5 per cent water of hydration has a strength almost as great as the tricalcium silicate with 11.5 per cent, whereas the tricalcium aluminate with 26.4 per cent has a strength of less than 100 pounds per square inch.

The dicalcium silicate hydrates to a very granular porous mass which allows of ready egress of solutions and, while it is chemically more resistant to the action of solutions than the tricalcium silicate, yet it furnishes a great number of voids in which salts may crystallize out of solution, and it is consequently very little able to resist the mechanical action of the "freezing out" (crystallization) of salts from solution.

On the other hand, the hydrated tricalcium silicate with its very dense structure, composed of gelatinous (colloidal) silicate interspersed with crystals of lime hydrate, is probably very susceptible to strains produced by alternate wettings and dryings, colloidal material of this kind being subject to considerable volume change resulting from slight moisture changes.

It appears, therefore, that the composition of Portland cement should be along lines which would not produce a great preponderance of either silicate. The ideal cement should possibly have an excess of the dicalcium silicate, which would give a not too dense hydrated material, gaining strength at later periods. A lesser amount of the tricalcium silicate would furnish the desired early strength and also overcome the excessive porosity of the dicalcium silicate.

It is possible to make a cement that will have the properties of Portland cement by grinding together the previously separately burned constituents in approximately the amounts in which they exist in Portland cement.

The function of tricalcium aluminate in the finished cement is somewhat problematical. A cement with less than 1 per cent of alumina has all the properties of Portland cement. Such a cement is, however, not a commercial possibility from the manufacturing standpoint, on account of the temperatures and amount of burning involved. To state, however, that the aluminate in the finished cement is of the nature of a diluent or inert material would be drawing a conclusion which, while justified by the present investigation, requires further confirmatory work.

The actual products of the hydration are those noted by Klein and Phillips[1], excepting as noted before the case of the dicalcium silicate, when apparently during the hydration of this compound lime hydrate is formed.

[1]Tech. Paper No. 43, this Bureau.

Wind Observations at the Nauen Radio-Telegraphic Station

In a communication presented to the Berlin Academy of Sciences (1917, pages 174 to 197), Professor S. Hellmann analyses the wind records from five instruments fixed on the masts of the Telefunken station of Nauen at heights of 2m., 16 m., 32 m., 123 m. and 258 m. above the ground, for the years December, 1912, to August, 1916. Some data from Potsdam and other points are included in the analysis. The most interesting feature is the diurnal fluctuations of the wind velocity, which is best explained by reference to graphs. Close to the ground the nights are generally quiet, and the wind velocity rises in the morning and descends again in the afternoon. This shows plainly on the graph for an elevation of 2 m.; at 16 m. elevation the curve is flatter, and the maximum is retarded from 12 P. M. or 1 P. M. At 32 m. elevation the curve is still flatter, and there is a secondary maximum about midnight. At 70 m. above the ground the curve is almost horizontal, *i. e.*, the wind velocity changes little in the course of the day; this fact is rather deduced, than directly observed. At 123 m. the curve is reversed, that is, the maximum velocity occurs about midnight, the minimum about noon; this is still more so at an elevation of 258 m. The phenomena are considered to be in accordance with the theory of Espy-Köppen, but the night effect is stronger than was assumed. Thus the wind velocity decreases first as we rise from the ground, and the maxima are delayed, especially in summer; in the higher layers, above 70 m. or 100 m., the opposite holds. The velocity maxima observed were: 4.1 m. per second at 2 m. elevation (between 1 P. M. and 2 P. M.); 5.3 m. per second at 16 m. elevation (between 2 P. M. and 5 P. M.); 8 m. per second at 123 m. (between 10 P. M. and 11 P. M.); and 10.5 m. per second (about midnight), at an elevation of 256 m. About midnight in summer the velocities at the five heights, 2 m., 16 m., 32 m., 123 m. and 258 m., were, for example, 2 m., 3.5 m., 4.6 m., 7.5 m. and 7.6 m. per second.—*Engineering*.

Revolving Fluid in the Atmosphere

The common assumption that cyclones and anti-cyclones are areas of revolving fluid is erroneous, as is seen when the actual paths of portions of air which compose them are traced. The motion of air in these forms of isobars is only instantaneously circular—the actual paths are compounded of the instantaneous motion of the air and of the motion of translation of the whole system, and are usually looped in shape in the case of cyclones.

Revolving fluid can, however, occasionally be identified in the southern area of a cyclone where a "secondary" is sometimes shown on the map, and it can be shown that the paths of air for revolving fluid which is moving bodily forward are a family of conic sections, similar in general appearance to the isobars of secondary depression. It is shown that in certain circumstances it is legitimate to assume that the isobars coincide approximately with the actual paths of air in these cases, and the conclusion is reached that the velocity of translation of the revolving fluid is that due to the distribution of pressure in regions near to, but undisturbed by, the revolving fluid. The conditions for permanence are: (1) That the column of revolving fluid must extend to the stratosphere. (2) That the velocity of the general current carrying the revolving fluid should be uniform at all levels, otherwise the eddy would be torn assunder. These conditions are not easily attained, but in favorable circumstances they can be identified in the southern portion of a cyclone, and in fact, it is that region whence two cases of revolving fluid which are given as illustrations are derived. One of these cases is that of a very destructive secondary, the other is that of a tornado which visited Wales and the west of England in 1913. The former is easily identifiable on an ordinary weather map as a secondary, the latter had a diameter of about 300 yards, and was therefore, not shown on the weather map. It is probable that the tornadoes of the United States are similarly related to the general distribution of pressure.—Note in *Science Abstracts* on a paper by N. Shaw before the Royal Society.

Using Low-Grade Minerals in Germany

The forced use of some raw materials in Germany which were considered too poor in peace times has been resorted to, according to *Stahl und Eisen*. This has been caused by the stoppage of imports or the advance in prices in Germany, due to the war. In several cases sufficient success has been obtained by new methods to justify the working of low-grade ores even in normal times. Thus, copper schists were hardly utilized when they contained only 2.5 per cent copper. Now ores of 1 per cent and even 0.7 per cent find utilization. As regards iron and steel there has not been much change, but poor pyrites and phosphatic ores are no longer rejected. The vanadium for steel is found in sufficient bulk in slags which do not contain more than 0.7 per cent vanadium; the wolframite of old waste heaps is a raw material for tungsten; chrome ore of 24 per cent is welcome—half the percentage formerly deemed worth mining—and sources of nickel are worked if they contain 1.5 per cent of nickel. Bauxite of 40 per cent aluminum is considered sufficiently rich. It is also stated that, after all, the aluminum can be got out of clay. There is no change as to arsenic and antimony. Sulphur, no longer obtainable as such, is gained from gypsum and anhydrite, and phosphates of 20 per cent are converted into fertilizer.—*The Iron Age*.

Effects of Heat on Celluloid and Similar Materials*

By H. N. Stokes and H. C. P. Weber

In 1907, at the request of the Steamboat-Inspection Service, the Bureau of Standards made a careful study of the literature of celluloid and other pyroxylin plastics and afterwards carried out an investigation of their properties with special reference to the hazard connected with their use and transportation. The results of the work are given in detail in this paper. In view of the present widespread interest in nitrocellulose products it seemed desirable to publish this paper, even though no account is taken in it of any advances that may have been made since 1908.

GENERAL NATURE OF MATERIALS

1. Composition.—Pyroxylin plastics may be defined as solid solutions or mixtures of pyroxylin or a similar material with another substance, usually camphor. Unless colored or containing opaque matter they are nearly transparent. Under gentle heat, combined with pressure, they may be molded into any desired form. Pyroxylin is essentially the same as soluble or collodion cotton, a material which finds varied applications and which is the product of the limited action of a mixture of nitric and sulphuric acids on cellulose, usually in the form of cotton fiber or rag paper. It is chemically a mixture of cellulose trinitrates and tetranitrates, while the allied guncotton is essentially cellulose hexanitrate, $C_{12}H_{14}(NO_3)_6O_4$. The properties of pyroxylin differ in degree rather than in kind from those of guncotton, both being highly combustible and under suitable conditions explosive, while both if not suitably stabilized are subject to spontaneous decomposition.

Numerous attempts have been made to reduce the inflammability of pyroxylin plastics by incorporating the pyroxylin with other materials than camphor, but these do not appear to have met with any success. Furthermore the camphor is occasionally replaced by other materials, as acetanilide, in the so-called odorless celluloid. These modifications are relatively insignificant and it may therefore be stated that practically all pyroxylin plastics made at present consist of pyroxylin and camphor, either alone or incorporated with varying quantities of inert material, such as zinc oxide. The usual proportion is about two parts of pyroxylin to one part of camphor. While certain variations exist in the method of manufacture, some of which have to do with rendering the pyroxylin stable, it may be stated that, apart from the minute differences introduced in the stabilizing process, all pyroxylin plastics are essentially the same as far as chemical composition is concerned except for inert material.

As the term "celluloid" is, in universal popular use, applied to pyroxylin plastics, irrespective of their source, and as no other convenient word exists, it is employed in its popular sense in this paper. (In its legal sense the term "celluloid" applies only to the product of one American manufacturer.)

2. Uses.—Celluloid is a component of innumerable manufactured articles in a greater or less degree. The following is a list of a few of the more important articles composed wholly or in part of celluloid: Brushes, combs, soap boxes, mirrors, and other toilet articles, collars and cuffs, table cutlery, photographic films, dental plates, smokers' articles, piano keys, plumbers' hardware, billiard balls, blank books and stationery supplies, surgical instruments, toys, corsets, phonograph records, harness and automobile trimmings, mathematical and drafting instruments, hats, and shoe eyelets. Often the amount of celluloid is quite insignificant.

DECOMPOSITION BY HEAT

It is well known that guncotton and pyroxylin cotton, if not properly stabilized, are subject to spontaneous decomposition, which in some cases may be sudden or explosive. Whether celluloid, which contains about 65 per cent pyroxylin, ever undergoes decomposition at a temperature within the range of ordinary atmospheric variations does not seem to have been settled conclusively. Cases are on record of such decomposition, but these either date from a time when the handling of nitrocellulose was not as well understood as at present or on closer examination it does not appear certain that external causes may not have been at work, such as exposure to an undue amount of heat or, in the case of fires in celluloid works, to accidental ignition of the vapors of solvents. We have not been able to obtain any unimpeachable evidence that at normal or slightly elevated temperatures celluloid ever takes fire spontaneously. Several series of experiments indicate that at 60° C. (140° F.) celluloid loses weight very slowly through volatilization of camphor and residual traces of solvent, but that at 100° C. (212° F.) the loss is much more rapid and is accompanied by decomposition of the pyroxylin itself.

The fact that pyroxylin and guncotton can be brought to explode is a sufficient indication that the decomposition is exothermic—that is, that heat is evolved, not absorbed, during the decomposition. There is no reason for supposing that this exothermic property will be changed by mixing with another substance, and, in fact, it is easy to prove that it is not changed. Experiments show that celluloid, if so insulated as to retain the heat and exposed to a temperature of about 135° C. (275° F.) attains a higher temperature[1] quite rapidly. This is because heat is evolved during the decomposition and is prevented from escaping. The more perfectly the heat is kept in the more quickly the temperature rises, until the celluloid finally reaches the point of sudden decomposition. The decomposition of celluloid is, therefore, different from that of materials like wood, cotton, etc., in that it is accompanied by noticeable evolution of heat and that if this heat is kept from escaping the temperature rises continuously.

Celluloid does not contain enough oxygen for its complete combustion, nor, in fact, enough to convert it entirely into permanent gas, but the heat is sufficient, if suddenly liberated, to volatilize it, with the exception of a trifling residue of carbon. It has been abundantly shown by others, and we have constantly observed, that if celluloid is raised to a certain temperature, it suddenly decomposes or "goes up in smoke." While this decomposition is not explosive in the sense that it is directly able to shatter objects with which it is in contact, it is nevertheless closely analogous to true explosion, and the large volume of gas produced is able to burst its container or to explode if mixed with air. If a piece of celluloid, open to the air, is touched with a hot wire, decomposition occurs at the point of contact but does not usually spread unless ignition ensues. This is because the heat of decomposition is conducted or radiated away too rapidly. If, however, the celluloid is kept in a confined space, the decomposition spreads rapidly. If strips of celluloid are placed in a long glass tube closed with a perforated stopper, and the upper part of the tube is warmed at one point until decomposition starts in one spot, this spreads rapidly down the entire length of the tube and torrents of inflammable gas are given off. If a hot object is dropped into a box of celluloid and the lid is instantly replaced, the reaction spreads rapidly through the entire mass and is in no wise interfered with by plunging the box under water. From this it is obvious that it would be very difficult to check the decomposition of a mass of packed celluloid by means of water, and the more careful the packing the more difficult it is to check. When celluloid is in thin sheets and loosely packed, however, it is not difficult to check its decomposition because, on account of the more ready access to water, the material is quickly cooled below the temperature at which the reaction can proceed.

Experiments were made in which a mass of wrapped celluloid was heated by a steam coil, the temperature of which did not exceed 120° C. (248° F.). The temperature in the interior of the mass rose gradually above that of the steam coil until sudden decomposition occurred, the whole mass of material being converted into suffocating and inflammable gas in a few moments. In some cases the escaping gas ignited (no flame being in the vicinity), while in every case the cotton wrapping was found to be glowing, and access to the air was sufficient to start a flame. What the resultant temperature was can only be surmised, but it was at least sufficient to melt the lead steam coil, even through the thick cotton wrapping.

It is also shown that celluloid heated in a box at 135° C. (275° F.) decomposed with a flash, and that the pressure of the exploding gases, in a relatively large space, was sufficiently great to burst open the door and bend at right angles the brass latch, which was 2 mm. thick.

To repeat, there appears to be no good evidence that pyroxylin plastics often inflame spontaneously or that they are directly explosive under any conditions. They present a marked analogy with explosives in that they undergo at an elevated temperature a very rapid and, under certain circumstances, entirely uncontrollable decomposition. The exact point at which this occurs is of secondary importance, because it is the culmination of a process of slow decomposition which begins at a much lower temperature and which proceeds the more rapidly the more perfect the retention of heat through packing and insulation. It is equally impossible to fix a point at which this process of slow decomposition becomes dangerous, as this also depends on the degree of insulation. It is sufficient to say that the best material we have been able to obtain can be brought to the sudden decomposition point if kept in an environment of 120° C. (248° F.), while with more perfect insulation, or in larger masses, it might decompose at lower temperatures. The above is a temperature to which it might easily be exposed in the case of a fire in the same room, without being in contact with it. The result of this decomposition is the sudden evolution of large volumes of hot gas which, on coming into contact with the air, are likely to ignite of themselves, or if not, then to form a highly explosive mixture, which will contain large but varying quantities of carbon monoxide and oxides of nitrogen, both of which are poisonous and the latter very suffocating.

[CONCLUDED ON NEXT PAGE]

*Abstracts from Technological Paper No. 98 by the U. S. Bureau of Standards.

[1]This effect is noticeable even at lower temperatures, but at 135° C. this becomes quite marked without providing particularly effective heat insulation.

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Effects of Heat on Celluloid and Similar Materials

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COMBUSTIBILITY

The term "combustibility" may mean either the ease with which combustion is started or the rate at which it proceeds after starting. As is well known, these are entirely different things. The definition of the ignition temperature is uncertain, as in the case of materials which give off combustible gas on heating; the ignition temperature is that of a mixture of the gas with varying amounts of air, rather than of the solid itself. In this respect celluloid resembles wood, but the temperature of decomposition is much lower than that of wood, as is also the ease with which it may be ignited. It is not possible to set fire to a pine board by holding a match to its upper surface, yet we have frequently easily and permanently ignited a heavy plate of celluloid, one-half inch thick, by holding a burning match to its upper surface. It is possible to ignite a plate of sealing wax in the same way, but unlike celluloid the flame does not spread and dies out in a few moments.

If by "combustibility" is meant the rate at which a flame once started is propagated, then it is shown by the results of our experiments that a thin stick of celluloid is five to ten times as combustible as a wooden stick of the same size under the same conditions. We soon reach the limit of size of a wooden stick which can readily be ignited and which will continue to burn if held horizontally, while a larger stick of celluloid will burn easily.

In any sense, therefore, celluloid is much more combustible than wood under similar conditions, and the flame is not as easily extinguished. It is not the celluloid which burns, but the gas evolved from it, just as is the case with other materials burning with flame. While wood has to be heated either from without or by its own combustion to cause it to give out inflammable gas, celluloid, if in a confined space, generates by itself enough heat to support a decomposition once started, entirely apart from actual combustion. It is therefore impossible to stop the progress of decomposition by shutting off the air, and inflammable gas will continue to be generated. Celluloid has been ignited with no greater initial source of heat than an air bath at 135° C. (275° F.) and has been caused to set fire to cotton and to its own gas, using no source of heat other than a steam coil at 120° C. (248° F).

It should be distinctly understood that this Bureau is not expressing the opinion that "celluloid" and pyroxylin plastics in general constitute an unusual source of danger in use. It would be no more just to condemn them in this connection than it would be to warn the public against the use of petroleum, of cotton fabrics, and the like. It is, however, right that the very inflammable nature of these materials should be known, as they fill a very important place, and it can only be urged that the same intelligence be used in handling them as is used in handling other highly combustible materials which are to be found in every house or which are worn on the person.

There was found to be no essential difference in composition and behavior between the products of the two American firms whose material was examined or between these and goods of foreign manufacture. Some samples are more stable than others, but this has no connection with the source. We therefore regard the different makes of pyroxylin plastics that were obtainable in 1908, so far as we have examined them, as on the average equally safe, or unsafe, as the case may be.

Tobacco, Fleas and Plague

IN an interesting paper under the above title in the February number of the *Indian Medical Gazette*, Mr. S. Mallanah, of Hyderabad, Deccan, reports that tobacco kills fleas practically instantaneously, and his suggestion is that tobacco leaves can be used as a preventive measure which will stamp out plague. He finds that when tobacco leaves are spread over the floors of houses where people sleep the fleas as they enter the rooms perish, with the result that there is no subsequent infection. In his investigations some 52 houses in highly infected areas were "tobaccoed" according to his method. The leaves were stitched on to a piece of matting and laid on the floor. The same number of houses of the same type and in close proximity were left untouched as controls. In spite of the fact that the floor was strewn with tobacco, plague here and there did break out—a fact which the writer attributes to faulty technique, while the number of houses tobaccoed which enjoyed complete immunity was certainly remarkable. Out of 52 houses which were tobaccoed only one house got infected (and that, it is stated, not through the fault of the tobacco), and out of 52 control houses seven got infected, which shows that the tobacco apparently failed in 14.2 per cent of cases and succeeded in preventing plague in 85.8 per cent of the cases under experiment. In conclusion, the writer expresses his firm belief that if the Government spent a fraction—he suggests one-eighth—of what it has actually spent in carrying out his method it would "save the misery and devastation of thousands of homes caused by the appalling death-rate from this calamity." Tobacco, of course, is a well known insecticide, but we are not aware that it has before been reported as being so prompt and effected a pulicide.—*The Lancet.*

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THE * INDICATES THAT THE ARTICLE IS ILLUSTRATED